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THE TELEGRAPHIC JOURNAL AND

ELECTRICAL REVIEW.

VOL. XXV. NOVEMBER 29, 1889. No. 627.

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THE ELECTRIC LIGHT IN RAILWAY TRAINS.

It is with much pleasure we notice the continued success of the lighting of the two main line London, Manchester, and Liverpool trains, each of which traverses the Midland system twice daily. These were the first trains started, equipped so that each carriage should carry its own lighting power, with a sufficient reserve to serve for a given period. The mere installation of a system for train lighting is materially different from that of a stationary or house installation. In the latter we have a fixed quantity and a stable power to deal with. In a railway train all this changes. The composition of the train depends very much upon the traffic; one day it may be that the number of coaches for a given place is ten, another day eight, and so on. The quantity with which we have to deal is never stable, and seldom predetermined, whilst the speed at which the train travels is always variable to the extent of the maximum which it may reach. The speed is a branch of the question which only enters where the driving of the dynamo is effected from the wheels of the train; but so far as electric lighting for railway trains has progressed in this country it has only been successful when applied in this manner. Having regard to the necessary complications which this must involve in order to meet the varying speeds, it is very strange that such should be the case; and it is, perhaps, to be accounted for only by assuming that opposition has attended the introduction or the application of other means of driving the dynamo in a more direct manner. With the dynamo attached to the wheels there must be more than one difficulty to contend with—speed and direction for instance. The dynamo must not come into circuit till a certain speed has been attained; it must again go out of circuit when the speed is reduced to a given point; and if the direction of the vehicle is reversed, the brushes must be reversed—at least, so far this has been the case. A dynamo run direct from the locomotive would be simply turned on when the engine was coupled on to the train, and would continue to pour forth its current so long as the engine remained so attached. The running would be more regular, the current would be absolutely continuous, and there would be a general advantage all round. These facts, we are satisfied, must be known, and well known, to those who have been labouring to introduce into our railway carriages not only a good readable light, but a light generally acceptable to everyone. There is, therefore, but one conclusion to arrive at, and that is that our railway electrical engineers have not met with that favourable consideration in the prosecution of that which all must regard as in the interests alike of shareholders and travellers which ought to have accompanied their efforts on the part of those who watch so jealously over the locomotive department.

Whether our conclusions are correct or not, all those who have travelled by the trains which are now lighted by the electric current, whether on the Brighton, Midland, or other lines, will not be slow in acknowledging the advantage of the light, and wishing it a speedy general application. For some years the Brighton Company, under their electrical and locomotive engineers, Messrs. Houghton and Stroudley, strove most assiduously to work out the problem of its application to trains *en bloc*, *i.e.*, to trains which were not broken up. They succeeded, and we have several such trains on that line running so equipped. Probably without their efforts we might not even now have experienced its advantages. Thus far, the Brighton Company pioneered the way; but none will deny the great advance secured by the Midland company's experiments. To the Midland Board and their electrician, acting under their authority, is due not merely the confirmation of the Brighton Company's work, but the completion of that which was begun by the pioneers. We understand that the Midland trains have now been running without interruption, being daily broken up on the journey, and at its termination, since May. The experiment, as an experiment, should by this time have

satisfied all of the practicability of what is sought. All who have had to do with electric lighting will know how much depends upon good joints. How Mr. Langdon and those who are working with him have managed to secure that good continuity so necessary to electric lighting, and to thus maintain it we are unable here to explain, but we have the broad fact that it has been and is daily being done. We have, moreover, the equally important fact of an equable distribution of the current throughout the several accumulators in the train. In the face of these results we feel that the Midland, once more to the fore in pioneering a well merited and long sought for improvement, has cause for congratulation. We wish them, we need not say, every success; and we hope that with such results before them the Board, not only of this company, but of other companies, may see their way to that further simplification of the application which will certainly result from the connection of the dynamo with the locomotive.

The subject is one which in every way deserves the attention of railway companies. A better light has been the outcry for years. The better light is now within reach. The question which no doubt will, more or less, agitate the breasts of officials and railway directors alike is that of the cost. We are scarcely in a position to go into this part of the question, but of this we feel sure that it will, light for light, prove in this case, as in all others where properly applied, the most economical. In considering gas we have to take into consideration many attendant expenses which have not generally appeared, and none of which attach to the electric light. Whatever may be the cost of gas the electric light, now that its application is shown to be feasible, should readily compete with it, and, we believe, as readily prove itself less costly—light for light, it will certainly do so.

That the matter is making that progress which marks its approval is shown by the fact that—as we understand—the Midland is merely waiting certain results to proceed with the fitting up of more trains, whilst we hear that both the Brighton and Great Northern are putting in hand several *bloc* trains. We also see it announced that the Cheshire lines have fitted a train to run between Manchester and Liverpool, to be followed by others.

CO-OPERATIVE TELEPHONES.

"COMING events cast their shadows before." The expiration of the celebrated "Bell" Telephone patent on December 9th, 1890, is now so freely discounted that the cessation of this unique monopoly at that time is proposed to be taken advantage of by the introduction of a system of cheaper telephony. This is to be accomplished under a "Co-operative" system, and a movement has already been set on foot in Manchester to endeavour to obtain this result. Circulars have been issued to the commercial community in Manchester, including, of course, all those now subscribing to the local exchange, "in order to ascertain the extent of support that would be given to an Association on Co-operative principles." The reason given is that much dissatisfaction exists at the high cost of the present telephone service. We, however, remember that some little time ago an agitation was got up against the existing arrangements, not only on this ground, but also on the great inefficiency of the service. This latter complaint was taken in hand by the Lancashire and Cheshire Company, who, at very considerable expense, altered their tactics by bringing their three exchanges into one, introducing a new arrangement of switch boards, and by other means succeeded in remedying the defects to that extent that the service was efficiently carried out and complaints ceased. The present agitation does not call for sympathy on that ground. We may mention here that under the direction of the new control of the National Company all trunk lines are now being carried out with metallic circuits, thus involving a very large increase in cost of construction, but obtaining an increased efficiency.

We give the following extracts from the circular:—

"As the work of organising and constructing will occupy considerable time, and as renters must give 12 months' notice of withdrawal from the existing company, it is necessary that the co-operative telephones should be established at once, in order to be ready to begin business when the patents expire under which the present monopoly is maintained.

"Estimates have been prepared by a competent engineer which show that the establishment of an exchange of 1,500 users will require a capital of £12,000, and will cost yearly for maintenance about £6,000—or, say, for each user about £4 per annum. The cost of private telephones in offices and warehouses would not exceed £1 per annum each, which would give users the great convenience of instruments in every department for a trifling charge.

"Arrangements are in progress for an inter-town telephone service, particulars of which will be given in a future circular." We do not think this future circular likely to appear; it will not be required, the present one being evidently more than is necessary.

The question of this telephonic opposition has evidently been looked at and considered from one point of view only, that is, the favourable point, and the adverse arguments appear to have been neglected or put on one side as not worth consideration. The figures given in the estimate are undoubtedly very considerably beside the mark, and must have been drawn up without a thorough knowledge of the difficulties of telephonic construction and maintenance. We do not think that the competent engineer referred to had the necessary opportunities to enable him to estimate with any degree of exactness—it is with regret we say so, as his untimely end has been only recently announced—the difficulties of the construction of telephone lines. The one question of "wayleaves" alone is a difficulty of so great a nature at the present time, that the existing companies and the Post Office, even, are sometimes at a loss to overcome the obstacles and the objections offered.

Granted that no difficulties are in the way, is it likely that a network of telephone main lines and branches (and to be efficient the circuits must be metallic) will be carried out from centres and attached to subscribers' offices within the time mentioned? Is it possible that on the 10th December, 1890, this "Co-operative Telephone" will have 1,500 telephone transmitters, and all complete ready to affix to the ends of the new subscribers' wires? Such instruments, to avoid the monopoly, cannot be procured until after the patent has run out, and how long would it take in manufacturing them, unless, indeed, they are surreptitiously undergoing construction now.

We are surprised to see that the circular has attached to it so many influential names, and can hardly imagine that a small economy should have induced such people to back a scheme which, we must confess, to be of a somewhat wild and impracticable character. If the local company at Manchester had given one quarter of the causes of complaint that the London public justly *had* against the United Company we could understand such an opposition; as matters now stand, if the subscribers carry out the suggested idea, they will place in the hands of the company an excellent method of retaliation.

THE authorities of the United States agree with Mr. T. D. Lockwood in considering the charges made in England for postal telegrams sufficiently cheap, and have fixed the rate for Government telegraph messages at a minimum of one cent. per word upwards, according to distance for day messages. For night telegrams the rate starts at three-fifths of a cent.

THE present administration of the U.S. Signal Office has given up the intentions of a predecessor to increase its telegraph facilities, and appears to be more bent on reducing the mileage of the lines under its control. It is about to abandon several lines on the Western Coast, which will shortly be sold to the highest bidder.

WE fear, even if the law were so altered as to bring electrical quacks and their works nominally within its clutch, that the trade would still flourish despite of all the pains and penalties that might be attached to the breach of any of the clauses of the new enactment. From experience in other countries we might safely predict that a public prosecution would only act as a cheap advertisement and add an additional stimulus to the already large but nefarious business. In the year 1842 one Montius kept a magnetic establishment in Brussels, and he gained a reputation for curing diseases; one of his remedies consisted in placing a couple of magnetised (*sic*) cylinders of glass crosswise in the patient's hands. The report of these cures brought numerous invalids to him in the hope of speedy relief; at length the Medical Faculty brought him before the "Tribunal Correctionnel" of Brussels—charging Montius, under article 19, of a law dated 12th of March, 1813, with illegally practising a branch of medical therapeutics. The Court condemned him to pay a fine of 25 florins. The result of the publicity was to increase his business threefold, for, whereas, before his conviction, he held two meetings a week to attend to his clients, he was now compelled by press of numbers to hold meetings every day in the week. Fined again and again, he continued his profitable course for some years; the system was based on the principle of small profits and quick returns, each patient being charged a fee of one franc for every attendance; besides, to make himself more popular still, he had, occasionally, free meetings, to which the poor could come without any expense to themselves. We believe the difficulty with the medical profession was overcome at last by keeping a medical practitioner to provide certificates authorising the magnetic treatment. What should we think at the present time if a leading morning paper were to insert such an editorial as the following extract from the *Courier Belge*?:—"Notwithstanding sentences of the court and constant ridicule, magnetism still thrives. One sees an ignorant Prussian peasant with a *clientèle* of 4,000 invalids, while some doctors of our acquaintance have not even a dog to attend; headaches, rheumatism, toothache are cured for the paltry sum of one franc a head. If one had to pay a hundred francs down he would be worthy to enter the learned profession; but a franc! Oh, fie! I would rather keep my headaches all my life! And I my gout! And I my epilepsy! For, as one good fellow has said, all these cures can be but the work of the Devil, who has been permitted to ensnare suffering humanity. There may be some truth in this saying, as the whole town crowds around this Montius. Apparently in these days, more than ever, people like forbidden fruit." . . . . "Academics have decried vaccination, the circulation of the blood, and even the existence of the air, but they have been obliged eventually to admit the truth, and so it will be with magnetism."

THAT electricity might appear to be a subject with which this Prof. Montius was well acquainted, he published a table showing the interpretation to be given to Thunder for each month of the year. January.—Heat, plenty of fruit, and high winds. February.—Great mortality. March.—High winds, little fruit, quarrels. April.—Great joy and plenty of crops. May.—Famine. June.—Abundance of corn. July.—Loss of pigs and fat lambs. August.—Joy, prosperity and lots of illness. September.—Heavy crops of corn, fruit, and much wealth. October.—High winds, rain, and good vintages. November.—Long peace, friendship and kindness. December.—Big war.

SHAREHOLDERS and others interested in the City of London and Southwark Railway have been anxiously enquiring for some time past as to the prospect of an early completion of this new enterprise, but it seemed difficult to obtain satisfactory information. A stir, however, was made last week, when Major-General Hutchinson, on behalf of the Board of Trade, inspected a portion of this underground line and witnessed, with Mr. Spagnoletti and a few other officials of the company, an experimental trip with one of the electric locomotives which ran on a short section between the Monument, King William Street, and Great Dover Street, in the Borough. The rate of speed attained on this occasion was 30 miles an hour. In ordinary service each locomotive is to run at the rate of 20 miles an hour when pulling a train of carriages containing 100 passengers. According to some daily papers, the

inauguration is expected to take place at an early date. We have not had an opportunity of seeing the underground work, but judging from the slow progress made with the surface work at the termini and intermediate stations, we fear that several months will yet elapse before the line can be opened for public use. We understand that the contractors for the electrical equipment are well advanced with their work, and expect to be ready before the builders have completed their part. A rumour has been circulating in the neighbourhood of the Stockwell terminus to the effect that funds had been running short. We trust that this is unfounded; we are looking forward to a successful career of this important undertaking, as it will doubtless be the forerunner of other schemes of a like nature, and it may even be the means of inducing the directors of the Metropolitan and District Railways to adopt electricity for the propulsion of their underground trains in lieu of the present steam locomotives.

IF Mr. Prescott's paper on "Some Methods of Regulating Accumulators in Electric Lighting" had been read before one of our own scientific societies it would have evoked a long discussion taking up several evenings, perhaps. It contains many points upon which a diversity of opinion exists among the members of the English Institution of Electrical Engineers. We do not advocate long-winded and aimless speeches which are sometimes attempted; but taking the grain from the chaff, there is vastly more energy displayed in discussion here than there is in the kindred society at New York. In the present instance, at any rate, we were struck with the evident want of interest shown and the paucity of remarks in general concerning an able paper upon so important a subject.

IN our issue of last week, under the heading of "Innocents Abroad," we gave a report of the discussion on Mr. Lockwood's paper, "Electrical Notes of a Transatlantic Trip," and in the concluding remarks of the chairman it is really astonishing to find that a system of working so old as that of the double current or the plan of using reversals should in these days be attributed to so opposite a design as was originally intended. "The English telegraphic engineers have always taken the ground that a submarine cable was less injured by an alternating than by a continuous current." If we substitute "more" for "less," the statement would be about correct. It is so well known that alternating currents help to break down a fault that it would seem really idle to repeat the statement; but, on the other hand, many faulty cables have been kept working for some time by abandoning the reversals and working only with a positive current. The introduction of the alternating current working may be traced as first due to its being employed as a method to overcome the retardation caused by the induction on underground wires.

THERE is one kind of alternating current working which is very extensively used at the present time, and little or no attention appears to have been directed to the amount of mischief caused by it. In ringing up, by means of the magneto bell, to call attention on the telephone, few are aware of the powerful alternating currents induced by the magneto machine. We have not measured them by any apparatus, but, from frequent experience by receiving the currents, are aware of their very powerful character as compared with ordinary battery power. A fault so minute as to be almost inappreciable by ordinary battery testing will, in a very short time, under the influence of the magneto, develop into one of so serious a character as to render the wire useless. Under a system of working by battery currents such a fault would remain unnoticed.

WE have seen this tried on many occasions, and have noticed that a line under ordinary test would appear good, but in a few seconds, under the influence of the alternating currents from a magneto, would develop a fatal fault. With ordinary open wires such faults can be easily approached and readily repaired, but in multiple telephone cables, whether overhead or underground, the matter assumes a more serious aspect. Taking the case of a multiple cable where one or two wires are not absolutely perfect, but only very minutely faulty, under ordinary signalling with battery power, these faults would remain dormant, but under the action of the magneto alternating powerful currents, they would soon become active, and finally render those wires useless. It is, therefore, we think, a matter for serious consideration with telephone companies whether it would not be better to employ a bell and battery for call purposes on multiple cables rather than the prevailing form of magneto. This form of power possesses many advantages over that of the ordinary cells, but under the circumstances we mention, which we know to exist, are not these advantages very considerably counterbalanced?

THE Board of Trade has received an immense number of electric lighting applications, and doubtless many more have come to hand during the past week. It is but reasonable to expect that there will be many which will meet with little or no consideration. It is understood that no application will be dealt with which is opposed by the local authorities. There will be great opposition on the part of governing bodies generally, and we are afraid much of this will be actuated by a dog in the manger policy.

WE understand that the Silvertown strike is now practically at an end, and the directors remain victorious. Perhaps the first touches of real winter experienced during the past few days may have given the strikers an inkling of what was in store for them if they still held out; but, whatever the reason of their collapse, it is gratifying to announce the fact that the strained relations between the company and its men are well on the road to settlement. The demands made by the disaffected *employés* were of such a nature that had they been granted the prospects of the Silvertown works as a successful commercial concern in the future would have been seriously jeopardised, and the directors are therefore to be congratulated on their foresight and firmness. No doubt their position was made all the more impregnable by being able to execute orders through the medium of their French establishment, and the non-success of the strikers' delegates to induce the French workmen to come out must have had a very salutary effect upon the malcontents. The result should teach the managers of large works that it is well to have two strings to one's bow.

A SYNTHETIC STUDY OF DYNAMO MACHINES.

(*Continued from page* 498.)

VII.—PARASITIC CURRENTS—(*continued*).

In our last article it was shown how the iron of the armature cores has to be laminated in order to avoid the generation of parasitic currents; but it is necessary, in addition to the lamination of the iron itself, that the solid metal supports which carry the armature be out of the magnetic field.

Taking the case of a Gramme wound armature as in fig. 129 (page 497), there are several ways of mechanically attaching the core to the driving spindle. If the core is of iron wire, this may be wound on a non-magnetic pulley with end flanges firmly keyed to the shaft, fig. 133 (page 498). Since the lines of force enter the armature on the circumference only, no part of the support is interposed in their path. If some of the lines stray out of the core where it is most strongly saturated and take a short path through the interior, these lines will undoubtedly go through the support, and it is advisable, therefore, to make the pulley of a metal having a high specific resistance such

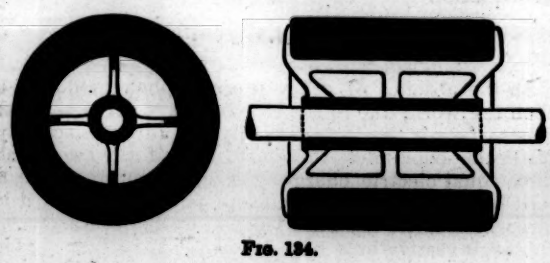


FIG. 134.

as delta metal. It is probable that the field straying in this way is in these armatures small, since the bottom layers of wire, owing to the magnetic discontinuity of the core, are saturated to a less degree than the layers above. Sometimes a skeleton frame or spider, fig. 134, is employed instead of a pulley. The iron wire is here wound between the end flanges, the spaces intervening between the four arms being filled up while winding with quadrant-shaped blocks of wood. By adopting this method the support for the armature is rendered less heavy, and by reason of the mass of metal being reduced the tendency to generate parasitic currents is diminished.

In constructing drum-wound armatures the iron wire may be wound on a spider, or it may be coiled on a bush fitting on the shaft and provided with end flanges, between which the wire lies as described above, accordingly as it is desired to leave an opening or not in the interior of the core for ventilation. The reason for interposing between the wire and the shaft the bush of non-magnetic material, is to prevent the shaft itself from getting magnetised and thus becoming a source of parasitic currents.

If the armature is of the disc type, fig. 131 (page 498), it is certain that the wire of the core can have no lateral support since the lines of force enter laterally, and a support here would mean something interposed directly in their path. The support is therefore in the form of a gun-metal pulley without flanges, on the rim of which the iron wire is wound. This wire is of rectangular section, in order that the necessary rigidity may be secured.

In armatures which have their cores built up of iron washers similar precautions must be taken as regards keeping the supports out of the field. In some small machines the method has been adopted of dropping the washers over a gun-metal pulley and tightening the whole up by an end flange threaded on to a screw cut on the pulley rim. There is nothing objectionable in this save that the support is heavier than if a spider were employed, while the tendency to develop parasitic currents owing to the stray field is greater. But in all but the smallest machines a spider or frame is employed.

In Messrs. Crompton's machine the armature is built up of charcoal washers about 25 to the inch insulated from each other, on the interior circumference of which are cut equidistant from each other, three or more dovetail notches as shown in fig. 135. These form, when

FIG. 135.

the washers are laid together, three longitudinal dovetail grooves from end to end along the interior of the core. In the driving shaft, which is swelled in the middle, are cut equidistant from each other, three deep grooves which come opposite the grooves in the core; and lying radially along the whole length of the armature, fitting one side into the grooves in the core, and the other into those in the spindle are phosphor bronze plates, B, by which the power is transmitted from the driving shaft to the core. It will be observed that the supports are out of the magnetic field, and that no currents can be induced in them excepting such as may be due to some of the lines of force straying across the interior of the core.

In Messrs. Paterson and Cooper's machines the core, also built of iron washers, is carried by three or more delta metal bolts as shown in fig. 136. Keyed firmly on

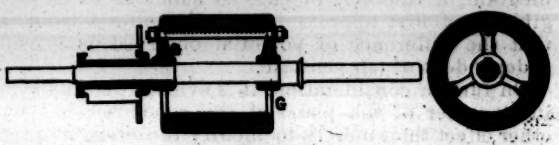


FIG. 136.

the shaft are two end wheels of gun-metal, G, G, through which pass the bolts which have a tightening nut on each end. There are cut in the washers slight notches into which the bolts lie, the latter besides serving to bind the washers firmly together, thus forming a positive driving attachment to the core. The supports here are also out of the field.

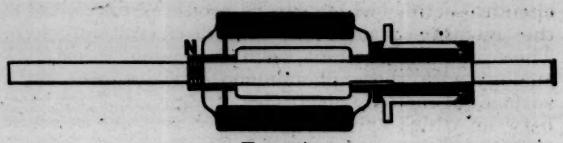


FIG. 137.

In Messrs. Mather and Platt's machines the core is supported by a gun-metal spider as shown in fig. 137. The plates each insulated from its neighbour by paper are, when placed in position, subjected to hydraulic pressure, the end flange being then tightened against the plates by the back nuts, N. In all these machines, which are Gramme wound, the lines of force entering on the outer circumference of the core have no supports interposed in their path.

If the armatures are to be Siemens wound, they may be supported in exactly the same manner if they are to have an opening in their centre, or if not the discs may be simply threaded on a non-metallic bush fixed on the shaft, and tightened up by nuts threaded on the

shaft and working against thick end washers, as shown in fig. 138.

If the armature is of the disc class with a core formed of iron ribbon on two or three sides of which the lines

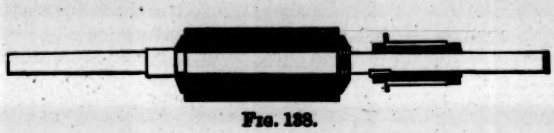


FIG. 138.

of force enter, figs. 130 and 132 (page 498), the support may be furnished by an interior ring of thicker iron carried by gun-metal arms or by the rim of a gun-metal pulley.

(*To be continued.*)

THE DIFFERENCE OF POTENTIAL OF METALS IN CONTACT.

THE origin of the difference of potential, or, to speak more exactly, of the electric charges which are observed when two plates of different metals are joined in circuit, has been for a long while a subject of much dispute.

Some electricians, clinging to the primitive ideas of Volta, consider that the phenomenon is a proof of the existence of an electromotive force originating at the surfaces of contact of the metals. Others, relying on the exceeding smallness of the amount which it is sufficient to oxidise in order to produce definite electrical effects, attribute the phenomenon to chemical action.

A short time ago M. A. Potier showed that the increase of charge which accompanies the bringing together of the plates of a condenser, entails a diminution in the energy of the system, and that only a very small fraction of the mechanical work produced is exhibited under the form of heat in the surrounding medium, a fraction, indeed, so small as to be negligible in a first approximation. It follows from this that the difference of potential observed is sensibly independent of temperature.

On further consideration, it is evident that the bringing together of the plates of the condenser has some other effect than merely to modify the charges on the opposite surfaces. Apparently, there is no modification in the interior of the metals nor at the surface of junction.

The energy of the system of surfaces depends on the density of the electric layer which covers them, and is modified when a definite quantity of electricity passes from one plate to the other.

The chemical theory already alluded to, appears to lead to the same or to a similar conclusion; but it is impossible to determine accurately the nature of the chemical actions which can be produced each time that the metallic plates are withdrawn or approached. These chemical actions seem to present a very great analogy with those phenomena which originate at the surfaces of metallic electrodes plunged in a liquid, and between which exist an electromotive force, or electromotive difference of potential, insufficient to determine the electrolytic action.

In order to express the apparent difference of potential at the surfaces of contact, Potier proposes to designate by the letters M, M_1, the amounts of energy per unit of surface of any two metals, and to consider these amounts as functions of the electric densities, ε, ε_1, at the surfaces of these metals.

Now, when a metallic circuit unites these two metals and one neglects, considering their comparative insignificance, the thermal effects, there will be a condition of electric equilibrium, if the energy lost by the system during the passage of a unit of electricity from one plate to another be equal to the work done by the electromotive forces, whatever be their origin, that is to say, to the difference of potential observed.

If V represent the apparent excess of potential of the metal M, over that of the metal M_1, then

$$V = \frac{d}{dz}(M_1 - M)$$

This value of V is, under ordinary circumstances, independent of the absolute charges. It is possible then to consider the variations of M and M_1 (*i.e.*, the amounts of energy per unit of surface) as proportional to those of the electric densities.

When the two metals, united by a conducting circuit containing an electromotive force, E, are immersed in a liquid of which the superficial energy is $L(\varepsilon)$ per unit of surface, the condition of electric equilibrium is

$$E = \frac{d}{d\varepsilon_1}[M_1 - L(\varepsilon_1)] + \frac{d}{d\varepsilon}[L(\varepsilon) - M]$$

And this condition, combined with the condition that the total charges of the liquid in the neighbourhood of the electrodes may be equal and of opposite sign, determines the densities, ε, ε_1, of each of these charges.

If, however, we consider a small volume, involving at the same time an "element" of the metal and an element of the liquid, describing on the surface of contact an area equal to unity, then its energy during the passage of a unit of electricity will be ascertained from the equation

$$\frac{d}{d\varepsilon_1}[M_1 - L(\varepsilon_1)] = -P_1$$

In the absence of every thermal phenomenon, P_1 is then the work, due to the electromotive force of which this surface is the *locus*, done by the unit of electricity. M. Potier concludes, therefore, that if the two metals have equal electric charges the electromotive force, E, will be equal to the difference of potential observed in air, which latter has been verified by Pellat for $\varepsilon = 0$.

The investigations of Lippmann upon electrocapillary phenomena, a full account of which appeared in the *Annales de Chimie et de Physique*, have shown how the superficial tension of mercury varies with the electromotive force.

Lippmann has demonstrated, also, the relation shown by the equation

$$dA + \varepsilon\, dP = 0$$

where A is the superficial tension which is, like P, a function of ε.

It is possible to deduce equally well from the experiments of Potier the relation which exists between dP and $d\varepsilon$; that is to say, that for acidulated water, P is known as a constant nearly with regard to the function of ε.

Further, it has been established for mercury by Lippmann and for platinum by Blondlot (vide *Journal de Physique*, *t*. X) that the form of the function $\frac{\delta P}{\delta \varepsilon}$ is the same for all aqueous solutions.

If, then, we decide from the experiments of Lippmann the value

$$P = \int(\varepsilon)$$

for any liquid whatever and any metal whatever, the electromotive force will be represented by

$$m - l + \int(\varepsilon)$$

where m and l are specific constants, and the normal state corresponds to no electromotive force.

This formula expresses all the facts known up to the present time.

When, however, it is desired to take into account the thermal phenomena alluded to in the early part of this paper, the above law can no longer be regarded as rigorously exact.

Experiment shows that superficial tension, and as a consequence the value of P, is variable with the temperature. It follows, then, from the principles of thermo-dynamics, that the passage of a unit of elec-

tricity from one plate to another is accompanied by an absorption of heat—the heat being abstracted from the surrounding medium if the operation be performed at a constant temperature. The difference of the potentials, V, is no longer

$$V = m_1 - m$$

but is equal to the sum of these quantities, and of the heat absorbed, of which the mechanical equivalent is $T \frac{\partial V}{\partial t}$. Hence reversible phenomena are instituted.

This absorbed heat constitutes the so-called "Peltier effect," and is an accurate test and measure of the electromotive force existing at the contact of the two metals.

The thermo-electric phenomena, however, have so very little importance, that the practical conclusions remain unchanged. It is sufficient to point out that they do not constitute an objection to, but are a necessary consequence of the theory proposed and argued by M. Potier before the Academie des Sciences, of Paris, recently; and which is practically this, namely, that the true seat of the electromotive force generated when two metals are placed in contact is found not merely at the point of contact, but on the *surfaces* of the metals, for on these take place those modifications which occur during charge and discharge.

THE WORKS OF THE INTERNATIONAL ELECTRIC COMPANY AT VIENNA.

[FROM A CORRESPONDENT.]

I AM now in a position to give you a detailed description of the Vienna works of the International Electrical Company.

The company in question has for this purpose acquired a plot of land from the Viennese Danube Conservancy Commission in the Engerth Street (No. II. district), forming a rectangle, surrounded on all sides by houses, and measuring 151 metres in length and 68 metres in breadth, and consequently forming an area of 10,300 square metres. Of this plot seven "*baugruppen*" (*i.e.*, land which would serve for constructing seven houses and their pertainings) have been at once taken in hand, and upon this plot there has been erected a boiler and engine house 48 metres in length, 30 in breadth, 10 metres in height, and open to the roof, with a chimney 40 metres in height and 2½ metres internal diameter. Next to this building is an open coal shed of wood and a one-storey dwelling house and offices 17·8 metres in length and 22½ metres in width, with a long cistern for working purposes, a well, and a drain for carrying off the rain-fall.

The electrical works in construction are planned for a total capacity of 12,000 horse-power, though in the first place only 2,400 horse-power is being installed, whilst the plant will be subsequently extended as it may be requisite.

For generating the steam-power required at present six tubular boilers (Steinmuller's system) are erected, each of 242·3 square metres heating surface, and adapted for a pressure of 10 atmospheres. The feed-water is passed into the boilers by three double plunger steam pumps (Worthington system), each having a cylinder of 229 millimetres, the diameter of the pumps being 133 millimetres, the stroke 254 millimetres, able to furnish each 40 cubic metres per hour, besides six injectors, each yielding 7,200 litres hourly.

The machinery consists of three compound condensing steam engines, each connected with a Zipernowsky alternating current dynamo of the type A 8, which at 600 effective (= 700 indicated H.P.) and 125 revolutions per minute produce each an electric energy of 380,000 watts, and lastly, three Westinghouse engines, each of 80 effective H.P., at 400 revolutions per minute and a pressure of 9 atmospheres; and each connected with a continuous current machine (for exciting the alternating current machines), of the type VP_8, each capable of furnishing 50,000 watts.

The condensing engines are so arranged that they, in case of need, can be used without condensation.

All the machines are erected on suitable foundations of concrete, their foundations being detached both from each other and from the walls of the building.

For conveying coal from the depôt and for carrying off the ashes from the boiler house there are laid down suitable tram lines with the necessary trucks.

For times of heavy work, *i.e.*, when the plant has to be enlarged to meet an increasing demand for electric power, there is a connection with the lines of the Danube bank tramway.

The requisite feeding and condensing water is taken from a well close at hand, on the bank of the Danube. From this well the water is lifted into the cisterns by the above-mentioned pumps, which are placed in the courtyard, and from there into a large reservoir, whence it reaches the boilers. Care, however, is taken that if required the feed water may be passed direct into the reservoir without touching the cisterns.

For the easier transportation of the heavy parts of the boilers and engines there is in the engine house a 20-ton crane running on rails.

All the electric machines employed in the works—as well for the alternating as for the continuous current—are arranged for perfect and safe parallel introduction. For this purpose all the needful switches, and instruments for measurement and control provided, are arranged in the engine house in a conspicuous and accessible manner, so that any insertion or transfer can be easily and safely effected by a simple movement of the hand.

The single light machines can be set in action or shut off by means of a large rheostat, a so-called substitution rheostat, consisting of wire resistances with two key boards, and capable of carrying an electric energy of 400,000 watts. This substitution rheostat, before connecting or disconnecting a machine, is pushed into its place, takes up the duty of the machine in question, and is then again drawn back, thus obviating the possibility of a sudden increase or decrease of the duty devolving upon any machine.

The entire system of leads—both the primary conductors leading to the transformers and the secondary supply conductors—are laid underground and consist of concentric double cables enclosed in iron. The net of cables promises to be very extensive, as the International Electric Company are carrying out their works with the application of alternating current transformers which are capable of undertaking the supply of electrical currents within the entire municipal district of Vienna. As a fact, applications have already come in from a number of consumers in different districts, including those in which the rival company has erected works.

In the erection of the works above described the company are already working with feverish activity. The walls of the building are already raised to the first floor, and every effort is made to secure the opening of the electrical works by July 1890, at the latest.

THE DISTRIBUTION OF ELECTRICITY IN THE CITY OF BRUSSELS.

UNDER the above title M. E. Bède, Communal Councillor, publishes in the *Ingénieur-Conseil* the first part of a contribution on the question of electric lighting, with which the authorities of Brussels are at present occupied. We take the following details from the contribution of the gentleman in question:—

We have already said that the aldermanic college of the City of Brussels had had the happy inspiration of combining its interests as a gas manufacturer with the interest of the persons under its Administration by offering, in a public appeal, the exclusive right of installing within its jurisdiction a distribution of electricity, power being reserved to take these installations

over after three, six, or nine years at prices determined in advance by those asking for the concession. The public appeal has been made; earnest competitors have presented themselves. Their propositions offer essential differences. The special commission appointed to examine them has not yet pronounced its opinion. The moment appears to me opportune for making known, without revealing anything as to the tenders sent in, what are, according to my opinion, the conditions of an advantageous concession for the City of Brussels.

Let us not lose sight of the essential basis of the project presented by the college, adopted by the commission, and approved, I believe I am able to state, by all those interested. The City of Brussels draws from the sale of gas a net revenue estimated at 1,550,000 f. in the Budget of this year. It has no interest in creating competition with an Administration which brings it in this revenue. If it did not wish to take account of the legitimate wishes of its customers, it might very well refuse electricity an entrance within its jurisdiction. Still, electricity would find a means of penetrating by the aid of private installations. Already large shops and *cafés* have established steam or gas motors working dynamos which furnish them the current necessary for their lighting. Groups of inhabitants also occupying premises situated in juxtaposition are solicited by electricians to subscribe to lightings established within these blocks of buildings, in which the authorities of the cities have no authority.

These private installations took away large consumers of gas, and consequently large revenues which are not compensated for by any receipts. It was necessary to arrest them as soon as possible. This could only be done by good public installations. The Communal Administration quickly occupied itself with the question of the distribution of electricity in order to cut short the supply within private houses. But the distribution of electricity is not a small matter. It is known that it has already absorbed, not a million, but tens and perhaps hundreds of millions (francs). The authorities did not wish to throw those which remained to it into the gulf which had swallowed those of men who thought themselves competent. It thought, with a great show of reason, that it would be better to let really competent contractors draw the chesnuts from the fire, instead of paying more dearly for the chesnuts if it were to draw them itself.

That being so, it was necessary that the authorities should look as well after the interests of their concessionary as their own, since it was their object to take his place. The concessionary was only a preparer of the work, a professor of installation and working charged with combining, realising, and putting the affair in order. For that he was to be paid. If the authorities should not take his place, that would show he had badly established his business, and it would be vexatious for him and the authorities. If this were the cause of non-success, either the bad choice of the concessionary or the conditions which the authorities imposed on him, that would be still more a matter of regret. It is necessary, then, that the authorities should choose a contractor who had given proofs of his ability as an installer and worker, and that they should leave him much liberty in order that he might arrange affairs in the best possible manner to prepare for them a good complementary administration to that of gas. But they must also, it is said, take into consideration the interests of its customers. It is here that it is necessary to define the special character of the needs which the enterprise must satisfy, and the rocks which it must steer clear of.

I have maintained, when it has been a question of the price of gas, the opinion that the authorities would abuse their power if they sold their gas at a higher rate than that at which companies offered to supply it. Means have not yet been found to manufacture gas within a private house, although the question has been ventilated. If the authorities said, "We do not wish companies to make a distribution of gas, nor to sell our gas at the price at which they would sell theirs," people would have the right to answer that they imposed upon their customers, and it is so much more blamable that they declare as dangerous and inconvenient the employment of the only competitor with their means of lighting—petroleum.

With electricity it is not at all the same. Every inhabitant can provide himself with an electric lighting plant at a relatively small expense, and a daily service which may be confided to the care of servants. The electric light may also thus be procured at a cheaper rate than that at which a company supplying electricity could furnish it, because it could only supply the electric current through conductors which are very costly. But people do not like the expense of a motor and a dynamo, and the cares of watching and keeping the apparatus in repair; they prefer to buy electricity at a price a little higher than that at which they could manufacture it themselves. That being so, it appears clear to me that the authorities are not bound to make any sacrifices whatever in order to exonerate certain of its customers from the expenses which they do not wish to incur, and from trouble to which they do not wish to be put. They should not even have, according to my view, the right to do it. The electric light is incontestably a light *de luxe*. The authorities, by making a sacrifice in order to supply it, would in reality make the mass of their customers pay for the luxury of the few. The small tenant, while looking at the house of a millionaire shining with light, the humble shopkeeper, while seeing the crowds attracted by the brilliantly-lighted windows of a large shop, the modest proprietor of a coffee house, while comparing his oil lamps or small gas burners, would be able to say to themselves it was at the expense of their pockets that all that luxury was obtained.

The authorities, according to me, should have but one care: to sell its electricity at the highest price they can obtain, without engaging the amateurs of electric lighting to supply themselves with electricity, either by installations within the house or by associations of common interests, by the formation of groups of lighting in a lump. This commercial problem is not easy to solve, and, when all the elements were well known, it is not surprising that its solution has cost many millions. Still, we must not lose sight of the fact that the problem was still more complex for electric light contractors who were not at the same time manufacturers of the gas with which they had to compete. The authorities of Brussels have not to occupy themselves with this competitor. On the contrary, they desired nothing better than to see it resist all the assaults which electricity might make upon it; because for a long time they could not gain so much by the sale of electricity as they could by that of gas.

In order to solve the simplified question which interests the authorities of Brussels, that is to say, in order to calculate the price at which the electric current could be sold, with pre-occupying themselves with the competition of gas, great experience of that kind of working was necessary; it was necessary to take into account all the elements which influenced the net prices. The most important of all is the redemption of the capital engaged in the installations. This figures for at least half in the net price. It is therefore very necessary not to exaggerate uselessly the expenses of dynamos and cables. That is why every serious contractor should, before all, assure himself of the quantity of electricity which he may have to supply in different directions, and for that to get in advance as many subscriptions. Here, from the very first, a danger presents itself: the future subscribers do not know how many lamps they will want. If it should cost them nothing to declare too large a number they will not fail to do so. He who wants 50 lamps will declare for 100, thinking that perhaps one day he will be able to place them. When the contractor has finished his list, and signed his subscription policies, he will find himself obliged to furnish current for 10,000 lamps and to supply plant for that number. Then, when the sale commences, he will perceive that he only furnishes current for 5,000 lamps. In his net price, calculated for 10,000 lamps burning 800 hours per year, there was 1½ c. per lamp

and per hour for the redemption of the apparatus and the conductor; this redemption, applying to only 5,000 lamps, will be 3 c. per hour and per lamp, and the contractor, who should sell his light at 5 c. per hour and per lamp, would lose, in this way alone, 30 per cent. of his net price.

How is such a danger to be avoided? Up till now only one single good means has been found: the payment of a fixed tax per lamp inscribed on the subscription policy, plus a tax proportionate to the current consumed. Thus, at Berlin, a charge is made of 6 marks per incandescent lamp of 16 candles, and per year 4 pfennings per hour and per lamp. The subscriber who indulges himself in the luxury of subscribing for 100 lamps instead of 50 pays 600 marks per year instead of 300, plus what he consumes. And do not let us imagine that the company makes a large profit on this kind of penalty of 300 marks inflicted on the subscriber who has exaggerated his provisions of consumption. On the contrary; if the redemption per lamp and per year is 1·5 pfenning, multiplied by 800 hours, or 12 marks per lamp and per year, it is clear that in getting a payment of 300 marks for the surplus 50 lamps declared, who cost the company 600 marks of redemption, it still loses 300 marks.

Thus, then, we cannot ask a contractor not to impose a fixed rate on his subscribers independently of the tax proportionate to the consumption of current. The prior reduction of this tax is at once very judicious and very equitable. It may be replaced by a minimum of consumption. The contractor may ask the subscriber who puts his name down for 100 lamps to pay at the least for the consumption of 100 lamps for 400 hours; that is to say, the wherewithal to cover at least the redemption corresponding to those 100 lamps, plus a part of the current consumed. That amounts to the same thing; but it is much less clear. With the system of fixed taxes the subscriber knows what it will cost him to ask for certain lamps for which he will have but a limited use. He will see, for example, if it suits him to pay 6 marks per year for power to light, if needful, a passage, a room, or a cellar where he goes only occasionally. It is his business to regulate these expenses; but he should not have the power to make the contractor pay for the lighting of his phantasies or his anticipations of probable light.

Let us remark also that this fixed tax bears equally and also heavily on the person who establishes a private lighting installation. The person who should fit up a lighting of 100 lamps would have to spend at least 7,000 f., for which at least 700 f. would have to be reckoned for redemption and interest, which would already represent, per lamp and per year, 7 f. of fixed tax, to be paid even if not a single lamp be lighted for a single hour. And if only a few lamps be lighted a day it would be necessary also to add to that charge the wages of an attendant who would have to be something of an electrician, and whom it would be necessary to pay at the rate of 1,500 f. a year, so that there would be a tax of at least 8 f. 50 c. per lamp and per year. For small lightings of 20 to 30 lamps the price of establishment, and consequently of redemption, per lamp being much lighter, the tax would also be higher, even if a simple servant were appointed to look after it.

A concessionary for public and private lighting who should not pay a fixed tax should, to do a good business, sell the electric current at prices high enough to cover the redemption of lamps not in use. If he succeeds in obtaining those prices he will pay to the subscribers who only subscribe for the lamps they need the expenses of the levity with which others have imposed useless installations. If it be objected that the concessionary may take this levity into account and only make his installation for a portion of the lighting asked of him, and which he engages himself to supply, we should answer that that concessionary would himself put much levity into his engagements. Two parties treating together on business have no right to regard the matter as not serious.

We find in the balance sheet of the Berliner Elektricitats Werke Company some interesting figures:—The value of the electrical constructions is two million marks. And it is necessary not to lose sight of the fact that only a small portion is occupied by these conductors. The central station of Mark Grafenstrasse cost 554,974 marks for ground, plus 66,625 marks for unfinished constructions and 954,980 marks for machinery. The Manerstrasse station figures for 499,179 marks for ground and 559,499 marks for machinery, plus 71,456 marks for machinery in construction and 19,577 marks for unfinished buildings. The Spandauerstrasse station reckons 416,916 marks for ground and 55,606 marks for unfinished constructions and 611,209 marks for machinery in construction. Lastly, the central station of Schiffbauerdamm shows 748,608 marks for land and 54,116 marks for unfinished buildings. The machinery is still in course of construction. We must add, to the properties which the company has acquired, land in Judenstrasse, Niederwallstrasse, and Marckgrafenstrasse, at a total cost of 454,830 marks. If to this be added the different values of the land mentioned above, the respectable total of 2,707,700 marks is reached. It is true that the company gets a large part of this land by building on the street front of shops which are let at very dear rates. In these cases it is necessary to instal its powerful engines in such a way as to produce neither noise nor unbearable oscillation. We have said that the new motor engines installed are all by M. P. van den Kerchove, of Gand, and that they work directly powerful Siemens and Halske dynamos. They certainly are model engines, the working of which is perfect.

All we have borrowed from the balance sheet of the Berlin company proves how much we were right in saying that the most important element necessary to be taken into account in estimating the net price of the electric current in a city is the redemption of the capital engaged.

Apropos of the above subject, the Moniteur Industriel announces that the authorities of Brussels are not disposed to grant to any of the companies who have at present tendered for the electric lighting of that city the entire concession of the service of distribution of electricity for lighting, but rather to divide the city into two portions, which would be conceded provisionally and for a trial period, the first to M. van Ryselberghe, who could instal and work his system of hydro-electric distribution, and the second to other companies who have tendered, and who would lodge the most advantageous tender for the contract. The two systems could, in this way, go through their trials, and, at the end of a certain period, when the experiments were conclusive, the one out of the two concessionairies whose system appeared the least suitable should assign his concession to his more fortunate rival, who would thenceforth remain holder of the entire concession. The same tariff would be applicable to the two rival concessions, so that the subscribers would be treated on the same footing. It seems from information received by our contemporary that the Commission has shown itself favourable to this project.

SEEING TO A DISTANCE BY ELECTRICITY.

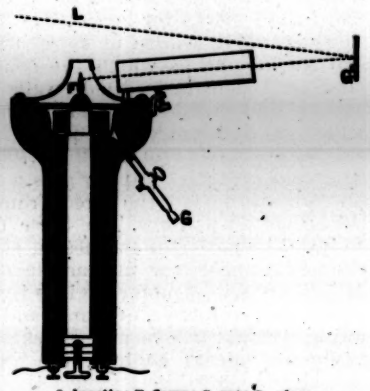
A CORRESPONDENT to *La Lumière Electrique* thus comments upon M. L. Weiller's paper which appears in *Le Génie Civil*, vol. xv., p. 570:—

The writer endeavours to solve the important question of vision to a distance by electricity, by means of a combination consisting of a selenium cell, a gas telephone and revolving mirrors, forming a special apparatus which he designates a phoroscope, and which we will briefly discuss.

The question of vision to a distance by electricity is governed by the two following fundamental principles. In order to get the impression of the form, outlines and details of one or several objects, it is not necessary—1. That the eye should receive all the rays

proceeding from it. 2. That it should receive, at the same time, the luminous rays necessary for vision.

Some very simple examples will demonstrate the first principle. We can see an object very clearly through wire gauze, and the image is perfect if the interstices are large and the wire fine. Carpets and mosaic seen at a certain distance do not seem to be formed of a number of parallel lines, or by the juxtaposition of little stones. An engraving, a picture, and especially a chromo-lithograph, show at a distance no discontinuity in the work, although the engraving is composed of lines and the chromo-lithograph of separate little dots.



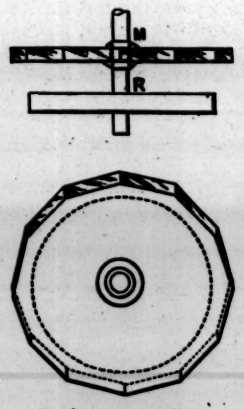
L, lunette; F, flame; G, gas; G_1, glass.

FIG. 1.

We see thus that it is possible to have a sufficiently clear perception of an object by the vision of a system of more or less luminous lines forming a kind of pattern.

The second principle is quite as well-known and as deduced from the duration of the luminous impressions upon the retina, a period of about $\frac{1}{10}$th of a second.

A series of impressions succeeding one another in a very short time produces the effect of simultaneous impressions, and it follows that in order to perceive the image which we have called the pattern, it is sufficient to receive the luminous impressions of the different lines that constitute it in an interval of time less than $\frac{1}{10}$th of a second.



M, mirrors; R, regulator.
30 revolutions per second; 360 glasses on the sides instead of 12.

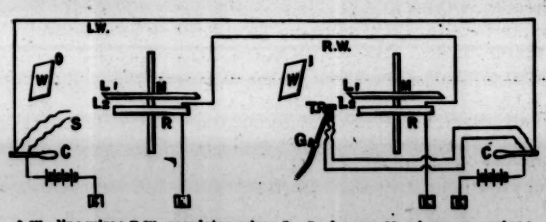
FIG. 2.

It was by taking this principle as a basis that Lissajous studied from an optical point of view the vibratory movements of bodies. His experiments are so well-known that we need not enter into them here. Lissajou's curves are produced in a rectangular portion of a picture. If, on the other hand, this object possesses the power of lighting, all the rays proceeding from the space occupied by the curve will, in an excessively short space of time, converge at one point after having been subjected to a double reflection on the mirrors of the two tuning forks that were employed for this experiment.

We may substitute for these forks any movable system whatever, bearing a series of mirrors arranged in such a manner that the displacement of each of them brings upon the same straight line all the rays projected from a portion of an illuminated object. Let us suppose these mirrors to be placed on a circle turning upon an axis perpendicular to its plane, and each of them making a different angle near 90° with this plane. To each mirror there will be a corresponding series of parallel lines in the picture, and if the rotation is sufficiently rapid all the rays proceeding from the object represented in the picture will meet at the same time, in as short an interval of time as required. It is thus possible to bring to one point all the luminous rays proceeding from a pattern, and each portion of the image thus producing its impression upon the retina in succession, it is sufficient that the interval in which these impressions succeed one another, should be sufficiently short for them to be rendered simultaneous.

The transformation of the luminous waves into electric currents is performed by means of a radiophonic receiver forming part of an electric circuit. This receiver may be a cell of selenium lamp-black, hydrogenated palladium, &c., the resistance of which varies with the quantity of light received. The different portions of the pattern will act differently according to the quantity of light emanating from them and in an interval of time less than $\frac{1}{10}$th of a second; the variations of resistance of the circuit will correspond to the image observed.

In order to solve the opposite problem, *i.e.*, to extract this image from the circuit at the receiving station, the writer proposes to employ the gas telephone, which is an instrument of extreme sensitiveness. It consists of an ordinary telephone (fig. 1) in which the portion comprised between the plate, the bobbin, and the inner sides is in communication with a gas pipe; the vibrating membrane is pierced in the centre with a little hole, through which escapes the gas which is lighted; this little flame will undergo a variation in brilliancy at each movement of the membrane, and it will produce a continuous succession of rays similar to those arriving upon the radiophonic receiver. In order to show them and form an image similar to the pattern, a system of mirrors is employed (fig. 2) similar to that used at the first station, but acting in the reverse way. It is evident that these two apparatus must act synchronically like the Hughes and Baudot regulators employed in telegraphy.



L.W., line wire; R.W., regulator wire; L_1, L_2, lenses; M, mirror apparatus; R, regulators; O, object; I, image; S, selenium transmitter; C, commutators; G, gas; T.R., telephone receiver; E, earth

FIG. 3.

Station 2 will reproduce upon a sheet the lines taken upon the image at Station 1.

The writer gives the name of phoroscope to an apparatus of this description, the different parts which we have described being combined according to the plan shown in fig. 3. The image that we wish to transmit is broken up into a series of parallel lines, the different points of which act in succession upon a selenium cell making the intensity of the current connecting the two stations vary. These variations in electrical intensity are transformed by the gas telephone into variations of luminous intensity, and the successive changes of brilliancy of the little flame are projected upon a sheet

at points corresponding to the various points of this sheet.

Theoretically, nothing can prevent this double transformation of luminous intensity into electric intensity, but the realisation of the experiment is surrounded with difficulties which make us fear that it will be long before a practical phoroscope is produced, but this should not discourage enterprising and persevering physicists.

REPORT ON THE APPLICATIONS OF ELECTRICITY TO RAILWAYS.

By MM. E. SARTIAUX and Z. WEISSENBRUCH.

THIS report summarises the proceedings at the third session of the "International Railway Congress," held this year (1889) at Paris.

The subjects especially discussed were the electric lighting of trains, the electric lighting of stations, the expense of working "Lucigen" lamps, the installation of electric lighting at the central locomotive works of the Belgian State railways at Malines; a paper on the question of the electric lighting of stations by M. Z. Weissenbruch; electric brakes; a paper on an electric brake, by M. Z. Weissenbruch; electric soldering, with a paper by M. N. de Bernardos; the transmission of power at the Choisy works (Paris-Orleans line); electric windlass (Northern of France); electric working of switches (Northern of France), and the electric capstan (Northern of France).

The question of the electric lighting of trains has been twice brought before the Congress, in 1885 and 1887, but without receiving due notice. It presents, as compared with the methods of lighting now in use, the following advantages:—Lamps of the desired illuminating power may be fixed at any point whatever in each compartment, and it is possible to obtain an absolutely steady light. This meets the increasing demand of travellers to read in the trains, especially on long journeys.

With electricity there is no longer any difficulty either about ventilation or lighting, nor is there any danger of fire or of explosion in case of collisions or other accidents. This advantage is particularly appreciable in America, where pretoleum lamps are especially in use, and where railway accidents are often followed by a conflagration of the carriages. The use of accumulators in each carriage renders it possible to obtain the complete independence of each carriage, as well as in any other system of lighting. At the same time the officials of the train can, by simply working a commutator, turn on the light at the entrance of a tunnel, or at nightfall.

Up to 1887 the electric light had not been finally adopted, except in certain high-priced trains in England and America, as in almost all experiments it was found more costly than other improved systems.

The results of more recent trials, if not decisive, are at least encouraging. For the electric lighting of a train, accumulators appear to be indispensable. It is not impossible to use at the same time another source of electricity, such as a dynamo driven either by the axle of the vehicle, or by a steam engine supplied by the locomotive. But accumulators remain indispensable for regulating the yield of the electric current, and securing a continuous illumination during the formation of trains and during stoppages.

Section 1.—Primary Batteries.

No new experiments have been made with primary batteries since the abandonment of the Holmes and Burke system, which was tried by the chief railways in England, and the Desruelles system, which the Pullman Car Company used for a time between Paris and Brussels. The great cost of this system has been the chief cause of its rejection. The batteries required close attention, but the light obtained was very fine. On the Paris-Orleans line technical difficulties contributed to the failure of the system. In a trial made in two carriages not in motion a short circuit was produced in one lamp in consequence of an imperfect construction. In the other carriage most of the lamps were burnt out, as the resistance of some of them was not sufficient.

In a second trial the lamps which were to have given the light of 6 candles for 24 hours gave only 4 at the outset; at the end of 12 hours it fell to 3, and at the end of 24 hours to ½ candle.

The number of the elements of the batteries was distinctly insufficient to realise the conditions required, although there had been placed under the carriages the greatest number of elements for which there was room.

According to Mr. Blodgett (*Electrical World*, July 9th, 1887), two unsuccessful experiments were made—one for some days on the Boston and Albany Railway, and the other for two or three months on the New York Central line.

Section 2.—Secondary Batteries.

The manufacture of accumulators, those especially with oxides and salts of lead, has latterly undergone great improvements. According to the experiments of Gérard, Prescott, Higgins and Kohlrausch, the best of these appliances have now a yield of energy exceeding 82 per cent., whilst in the earlier models it did not exceed 50 per cent. Their capacity in discharging reaches 12 ampère-hours per kilo. of plates, and 8 ampère-hours, or 8 ampère-hours per kilo. of gross weight, with a potential of 2 to 1·89 volt. We may even obtain 20 ampère-hours per kilo. of plates with the new *lithanode* accumulators. Lithanode is a cohesive and compact substance, formed of lead peroxide, and does not require a metallic case. But there are as yet doubts concerning their durability.

It is certain that these figures, deduced from laboratory experiments, will suffer a reduction in actual use, especially in consequence of the oscillation of the trains. But it appears from prolonged trials made by the Pennsylvania Railway and the Boston and Albany Railway with accumulators having the oxides applied mechanically, that we may count on a minimum yield of 60–65 per cent., and on a capacity of discharge of 10 ampère-hours per kilo. of electrode.

Practice shows that it is preferable to use glow lamps of feeble tension (23 to 28 volts). As it is easier to use reflectors with these lamps than with oil or gas burners, we may thus obtain an excellent light without exceeding 6 to 8 candle-power.

It is sufficient, with a potential of 23–28 volts, to have an intensity of current of 0·6 to 1·3 ampère, according to the system of the lamp. Now, the electromotive force of each secondary element, which is from 2·1 to 2·4 volts during charging, is from 1·95 to 1·75 during discharging with a current of normal intensity. A tension of 1·75 being reached only at the end of the discharge we calculate the number of accumulators by taking as a basis 2 volts per element, and adding a reserve of 3 or 4 elements, which are introduced successively into the circuit towards the end of the discharge.

There exists another arrangement which has been tried by the Northern of France, and which consists in intercalating in the circuit an automatic rheostat regulated at the outset according to the intensity of the energy consumed by the total lamps in one and the same carriage. This rheostat serves also as a commutator for lighting and extinguishing the lamps.

We may calculate the number of hours of lighting by setting out with a capacity of discharge of 10 ampère hours per kilo. of electrode. It is prudent, however, to keep below the figures thus obtained for the sake of the durability of the accumulators.

The quantity of electricity necessary for charging is 15 ampère hours per kilo. of useful weight. For safety's sake the yield of energy may be calculated at 60 instead of 80 per cent.

As regards the durability of accumulators the negative plates are very lasting. Some manufactured by the

Electrical Accumulator Company have been in daily use since December, 1886, and have not undergone any apparent deterioration. Their yearly depreciation is reckoned at from 5 to 10 per cent.

As for the positive plates, their annual depreciation was originally estimated at 50 per cent. A depreciation of 30 per cent. resulted in 1887, in certain experiments made on the State lines of Würtemberg, and again on the Boston and Albany Railway, and has been subsequently confirmed. If they are specially made for use on railways, and managed with care, it is admitted that they have a minimum durability of two years. In fixed installations they last longer. Mr. Preece has lately certified to the Society of Arts that he has had 26 Faure-Sellon-Volkmar elements in action for two years, which are yet in a perfect condition.

The Julien Company of Brussels guarantee a depreciation of 12 per cent., the Blanc Works, of Marley-le-Grand, 10 per cent., and the Faure-Sellon-Volckmar Company goes as low as 6 per cent.

It results, from recent experiments made on the Northern of France Railway that, thanks to recent improvements, the detachment of the paste reduces the depreciation to 25 per cent. The discharge of the batteries must not be too rapid. In accumulators where the solidity of the paste is insufficient, there is room for grave mistakes if the water is not renewed in time, and if the batteries are not daily inspected, in order to remove bits of oxide which might form short circuits.

The duration of the lamps was formerly taken at 800 hours, but by an improved construction of the lamps, and by submitting the filaments to suitable compression, it may be extended to 1,200 hours.

The above data are confirmed by experiments made on the Paris-Orleans line, on the Pennsylvania, the Boston and Albany, the lines used by the Pullman Palace Car Company, the Canadian Pacific, the North-East of Switzerland, the lines of West Switzerland, and of the Simplon, the Northern of France, the Helsingborg-Christiania line, in Sweden, and the Melbourne and Adelaide line.

(*To be continued.*)

SIR WILLIAM THOMSON'S CHAIN OF ELECTROSTATIC VOLTMETERS.

By ANDREW W. MEIKLE, M.A.

(*Concluded from page* 582.)

THE range of electrostatic measurement for ordinary practical purposes by the chain of instruments described above is complete from 25 to 50,000 volts, but, though little difficulty would be found in making an instrument, were it desired, to suit higher ranges, the problem of finding a convenient electrostatic instrument to give direct readings of potential below 50 volts is more difficult. No doubt a voltmeter of the multicellular type could be made with a lower range, but in order to do so the length of the suspending wire or the mass of the movable part would require to be increased to such an extent as to render the instrument very cumbrous, and at the same time difficult to observe on account of the necessarily long period of vibration which its indicator would have. For laboratory and accurate scientific work a means of extending the range downwards is provided in the quadrant electrometer, which can be used when adjusted to best advantage to measure from $\frac{1}{100}$th to 40 or 50 volts.

In the practical working of alternating installations it is seldom necessary to measure potentials so low as 50 volts, but for use with direct currents Sir William Thomson has invented a magneto-static voltmeter which gives direct readings from a small fraction of a volt up to 200 volts, and is found convenient for work with storage batteries and other purposes. A description of this instrument will be given in a subsequent article.

NOTES.

Lighting of the Newcastle Assembly Rooms.—The new assembly rooms were formally opened on Friday evening last. They are lighted with the electric light, the installation consisting of five large and handsome electroliers in the upper and five in the lower assembly rooms, and two to match in the supper rooms. Each electrolier has 13 lights, each of 16 candle-power. The lamps throughout are Edison-Swan 16 candle-power, and the total candle-power is about 5,500. The wiring is done in the most substantial and perfect manner, and the switches and cut-outs are of the latest, having been executed by Mr. R. J. Charleton, of Newcastle. At present the installation is worked by temporary generating plant, situated at the rear of the building, and this arrangement will continue until the Newcastle and District Electric Lighting Company is ready to supply from its mains.

Electric Lighting at Fareham.—A meeting of those interested in the Fareham Electric Light Company was held a few days since, when it was stated that the greater part of the share capital had been subscribed and that the company would shortly be incorporated.

Paris Electric Light Concessions.—*La Lumière Electrique* says that the concessions for electric illumination on the boulevards of Paris will probably be delayed six months.

Electric Light in Edinburgh Demonstrations.—The electric lighting for the Balfour demonstration in Edinburgh next week will include upwards of 600 incandescent lamps inside the building, and six arc lights for the entrances.

Dundee and the Electric Light.—Dundee Town Council, Police Commission, and Gas Commission at a joint meeting have resolved, with the view of securing the right for the city to introduce the electric light, that notice should be given of a Bill in Parliament, and also for a provisional order from the Board of Trade to supply the light, the three Boards to be parties to the notices, so that Parliament shall have the opportunity of determining which of them shall supply the light. It was further agreed to join with Edinburgh, Glasgow, and Aberdeen in making representations to the Board of Trade as to several amendments on the present Acts.

The Fowler-Waring Cables.—We hear that the Ferranti conductors have been abandoned between Deptford and London, and that Fowler-Waring cables have been substituted.

The Houstholm Electric Lighthouse.—This powerful electric lighthouse was opened a few weeks ago. The light is distinctly visible at Blokhus, a straight distance of about 35 miles. The only undesirable incident attending the working of the new lighthouse is the immense number of birds which get killed. The lighthouse is 209 ft. high, and the light power in the beam is 2,000,000 candles. To guard against the stoppage of the light through any accident to the machinery, this is, as far as it has been possible, constructed on the twin principle. There are two engines, compound, from the Elsinore Shipbuilding and Engineering Company, three tubular boilers, one of which is a particularly quick heating one (from the Walther establishment at Cologne, Germany), two electro-magnetic machines with a joint capacity of 45 volts, 250 ampères, from de Meritens and Co., Paris, two electric lamps, with various reserve lamps, &c.

Barnsley and the Electric Light.—It was unanimously resolved on Friday last to apply for a provisional order for the lighting of the borough.

Increased Light for the City.—At a meeting of the Ratepayers' Association of Aldgate Ward, held on Tuesday, a resolution was passed in favour of the better lighting of the City.

Contract for Lighting the Houses of Parliament.—The London and Westminster Electric Supply have secured the lighting of the Houses of Parliament.

Electric Lighting in the City.—The Laing, Wharton and Down Construction Syndicate have notified the fact that they intend to apply, either themselves or on behalf of a company to be formed and called the City of London Electric Supply Company, for power to construct a central station or stations for supplying the area of the whole of the City of London and its Liberties.

The Edinburgh Exhibition of 1890.—On Saturday afternoon the ceremony of cutting the first sod on the site of the International Exhibition, to be held in Edinburgh next year, took place in presence of a large assemblage. Lord Provost Boyd, who presided, said they were about to take the first step in an enterprise which they hoped would be of great advantage to art, science, and industry, and also of great advantage to the city of Edinburgh. The main feature of the exhibition would be the electrical department. They did not know very much about electricity in Scotland yet, and it was very desirable that they should know more. They had the advantage of the patronage of Her Majesty for this exhibition. The Marquis of Lothian was president, and there were a number of vice-presidents. An influential committee had been formed in London, of which the Lord Mayor had agreed to act as president, and Sir George Chubb was chairman of the committee. He was very glad the Town Council of Edinburgh had done what it could to promote the interests of the exhibition. Mr. Allan Carter, C.E., handed a silver spade to Lady Clark, and requested her to perform the ceremony of cutting the first sod. Before she did so, however, Sir Thomas Clark thanked the executive for the honour which had been conferred on her ladyship. He believed that some people had an idea that this exhibition had been introduced rather too soon after the exhibition of 1886, but there had been very good reasons for it. They were all aware that the Forth Bridge was to be opened soon, and a large number of scientific people from all parts of the world would be present on that occasion. Therefore, it seemed to be a most opportune occasion to take advantage of the presence of so many scientific people to show a collection of matters connected with electricity such as had never been gathered together before. They had promises from all parts of the world in this respect, and the little difficulties that were in the way with the Electrical Trades Section of London Chamber of Commerce had, he believed, all been got over, and now there would be a unanimous feeling throughout the whole of the electrical world that this exhibition should be made a great success.

The Executive Council of theExhibition is prepared to consider tenders for the lighting of the Exhibition buildings and grounds. Plans and specifications on application to Mr. George E. Watson, secretary, 27, Frederick Street, Edinburgh. Tenders to be lodged by noon on 3rd December.

Speed on Electric Railroads.—The best record is said to be 20 miles an hour; this, however, will be equalled on the London and Southwark Subway, though 30 miles has been attained.

The London Electric Supply Corporation.—This corporation has given notice that it intends to apply to the Board of Trade for power to produce, store, supply and sell electricity, electric current, and other like agency for public and private purposes within the area constituting the City of London and the liberties thereof. It is proposed to construct a station, or stations, at which to generate or collect electricity, and a system of distributing stations and mains from which to distribute the current. The company will ask for power to place lines in all the thoroughfares of the area of the City, and also to cross the River Thames, and to break open, or to otherwise interfere with, the Great Eastern, Great Northern, London, Chatham and Dover, London, Tilbury and Southend, the London and Blackwall, the London and North Western, the Metropolitan, the Metropolitan District, the North London, the Regent's Canal, City and Docks Railways, and the City of London and Southwark Subway, and the North Metropolitan Tramways.

Electric Bells at Fire Brigade Stations.—On Tuesday last, at the weekly meeting of the London County Council at the Guildhall (Lord Rosebery in the chair), Mr. Nathan Moss, chairman of the fire brigade committee, reported that that body had obtained tenders, as follows, for the supply and fixing of electric bells at the Shoreditch, Lewisham, and Blackheath stations:—

	Shoreditch.	Lewisham.	Blackheath.
	£ s. d.	£ s. d.	£ s. d.
Messrs. H. Binko & Co....	28 15 6	28 15 6	23 15 6
Messrs. Adams and Son...	37 0 0	31 10 0	29 8 6
Mr. Julius Sax	41 5 0	36 0 0	26 5 0

The tender of Messrs. H. Binko & Co. had been accepted by the committee. The council approved of the choice of the committee.

National Telephone Electrical Society.—At the meeting of the Birmingham Branch on Friday evening, the 22nd inst., Mr. Arthur E. Cotterell, vice-president, read a very interesting paper on "Disturbances on Telephone Circuits." The paper was illustrated with diagrams showing the various devices that have been adopted on telephone circuits with the object of minimising the effect of induced currents.

The Lighting of Morecambe.—Messrs. Andrews and Preece, electricians, Bradford, are applying for a provisional order for lighting the district.

The Lighting of Rochdale.—The Corporation has decided to leave the lighting of the borough to private enterprise. The Lancashire and Cheshire House-to-House Electricity Company, Limited, will apply for a provisional order.

Rapid Rise in Copper.—It is said, on account of large secret purchases made by the German Government, the price of copper is rising rapidly, and on Monday an advance of 10s. a ton was declared in the English market.

Ozone.—A letter, naturally from a seaside resort, requests us to say that the demonstration and lecture on "Ozone" at the Ozone works is, in consequence of the indisposition of Mr. Fahrig, postponed, but that invitations will be re-issued as soon as convenient. Probably a few of our readers may know something of this matter; we don't!

The Deptford Station.—We hear that trouble is being experienced with the engines in this station from hot bearings, which do not seem to be easily set right.

Institution of Electrical Engineers.—A students' meeting took place on Friday, Nov. 22nd, Mr. Barton in the chair. A discussion was held on "Cotton, Jute, and other fibrous substances, as Insulators," in which Messrs. Barton, Childs, Muir, Müller, Poynton, Tonge and Walker took part. This was followed by Mr. Childs with a description of the pumping and hauling plant recently put in at St. John's Colliery, Normanton. The next meeting will be on Friday, December 6th. Paper by Mr. A. E. Childs on "Electric Traction."

A Gas Director on the Competition of Electric and Gas Lighting.—Mr. H. McLauchlan Backler, the chairman of the European Gas Company, the Continental Union Gas Company, and the Oriental Gas Company, addressing the shareholders at the meeting of the last-named company on Wednesday, November 27th, said: "With regard to the electric light, no doubt we shall have, as everywhere else, some competition from electric lighting at Calcutta. I am sure we shall, in fact; but I do not think there is any reason to apprehend that our revenue will suffer any diminution—or, rather, any serious diminution—from it. I am chairman of a company where the electric light has obtained a real footing—perhaps a greater footing than in any city in Europe; but in that city, I am pleased to be able to say, that notwithstanding the competition of the electric light, the increase in the consumption of gas is greater than in any other city lighted by the same company. That city is one of the most important in Europe. I have no objection to mention it. It is Milan. That is not the only place. I also know, of my own knowledge, other cities in Europe where similarly favourable circumstances obtain in the competition between the two lights; so I do not think there is much to fear from it.

The Silvertown Strike.—We are glad to say that there are over 600 men at work again at Silvertown, and arrangements are being made to bring back the business to the factory as quickly as possible, so as to give employment to the rest.

Obituary.—The death occurred on Friday last, at his residence, 6, Pier Road, Erith, Kent, of Mr. Walter Hall, who had attained the age of 80. The deceased was a member of the Institution of Electrical Engineers, and had invented several electrical appliances. The illness was a brief one.

We regret to announce the death, at Shanghai, on the 13th inst., of Mr. L. M. Holst, the Great Northern Telegraph Company's Engineer in the Far East. Mr. Holst entered the company's service in China in 1874, and took an active part in all the company's first attempts to construct landlines and introduce inland telegraphs in the Celestial Empire, until he finally, in 1881, succeeded in completing the construction of the first inland Chinese telegraph line of any importance between Shanghai and Tientsin. Several routes were surveyed and many lines built under Holst's immediate supervision, and in recognition of his valuable services the Chinese Government decorated him with the insignia of the Double Dragon. In 1885 Holst was promoted to the post of superintending engineer in Shanghai to the Great Northern Company, which position he held when death suddenly interrupted his career at the early age of 39 years.

Extension of Telephones.—The South of England Telephone Company is just finishing an extension of its system at Deal, Kent, and the wire to Whitstable will be opened in another fortnight. The Ashford Trunk Line will then be commenced prior to the opening up communication between Maidstone, Chatham, and East Kent.

Fall of an Overhead Wire.—A telephone wire fell in Fleet Street on Monday; fortunately no one was seriously injured, although several persons were struck.

Edinburgh Exhibition (London Committee).—A meeting of the London committee was held on Monday last at the Mansion House under the presidency of the Lord Mayor. Mr. C. M. Kennedy, of the Foreign Office, moved a resolution commending the exhibition to the support and co-operation of the public.

A New Telephonic Service.—A City paper says a movement is on foot among business men in Liverpool, Manchester, and Glasgow to establish a telephonic service on a co-operative basis. The promoters of the project point to the high charges at present in force, and assert that for about £5 per annum a good exchange service can be secured.

Effect of Electricity on Gas Shares.—A provincial paper says that in Devonport gas shares have been affected to a great extent by the proposed introduction of the electric light. It is said that a month ago shares in the local gas company were sold at £12 10s., and during the last week a large number were offered at £8 a share.

The Supply of Electricity in Piccadilly.—A writer in *Truth* wants to know about electric lighting. Certain companies have secured monopolies for districts of London. Within these districts they are allowed to take up the ratepayers' pavement, and to use the ratepayers' roadway. But he understands that in Piccadilly and other districts they decline to supply light unless the householder will engage to use a fixed minimum of light during each quarter of the year. This pretension must, if legal, be dealt with by further legislation.

Utilisation of Power in Glasgow.—A correspondent to the *Glasgow Herald* suggests that power for driving electrical machinery be obtained from the upper reaches of the River Clyde.

Proposed Memorial of the Late Dr. Joule.—A public meeting has been held in the Mayor's Parlour at the Town Hall, Manchester, for the purpose of considering the proposal to erect a memorial to the late Dr. James Prescott Joule. The meeting was convened in response to a memorial influentially signed by residents in Manchester, Salford, and the neighbouring country, who desire that their "deep sense of the benefits conferred on mankind for all time, as well as of the great honour which accrues to this district, by the scientific work of the late James Prescott Joule, should be marked by the erection of some durable memorial of him in the city." There was a large attendance. The Mayor of Manchester (Mr. Alderman John Mark) presided, and in his opening remarks, spoke of Dr. Joule as a scientific man of the first rank whom the citizens of Manchester were proud to call one of themselves. Dr. Joule's great discovery, he said, had, like that of Dr. Dalton, contributed enormously to our material and industrial progress, and we could not estimate to what results it might yet lead us. Mr. Oliver Heywood moved: "That this meeting desires to mark its deep sense of the benefits conferred on mankind for all time, as well of the great honour which has accrued to this district, by the scientific work of the late James Prescott Joule, by the erection of a durable memorial of him in Manchester, in the form of a white marble statue." Sir H. E. Roscoe, M.P., seconded the motion, which was adopted. A committee was appointed to raise, by public subscription, a sufficient sum to carry the resolution into effect.

The Gilbert Club.—The objects in the formation of this club are to bring out an English edition of Dr. Gilbert's famous work "De Magnete," as nearly as possible in imitation of the fine folio edition of A.D. 1600. The work, of which a limited number of copies (say 200) are to be printed, to be brought out in the very best style; and to be issued to members of the club, whose subscriptions will defray the cost of printing. The value of copies will probably rise to several times the actual cost, which is estimated not to exceed one guinea. A very limited number of copies to be offered to the public at an advanced price, say two guineas, to lessen the cost to members of the club; also to arrange for the celebration of the Gilbert tercentenary in the year 1900. Among those who have consented to become members of the club are Sir William Thomson, Mr. Jonathan Hutchinson, F.R.S., Lord Rayleigh, Sir David Salomons, Mr. Latimer Clark, Mr. W. H. Preece, The inaugural meeting of the club was held yesterday at the rooms of the Society of Arts, for the purpose of electing president, general officers, and to determine the amount of the contributions, and arrange other details with regard to the publishing of *De Magnete*. Sir William Thomson occupied the chair. Prof. Thompson briefly explained the objects as set forth in the prospectus already published. A lengthy discussion followed, after which Sir Wm. Thomson was elected first president; vice-presidents Mr. J. Hutchinson, Lord Rayleigh, Dr. Henry Laver, Prof. D. E. Hughes and Prof. A. W. Reinold. The council is to consist of Messrs. Lant Carpenter, Foster, Forbes, Rücker, Ferguson and Sir Philip Magnus. Prof. Silvanus Thompson, Mr. Conrad W. Cooke and Prof. Raphael Meldola were appointed secretaries.

New Firm.—Mr. T. G. Poole and Mr. W. White have resigned their appointments in connection with Woodhouse and Rawson United, and are starting business as electrical and mechanical engineers, suppliers and factors, at 58 and 59, Bread Street, Cheapside, London, preparations being made to commence operations on the 1st December.

Electrical Trades Directory and Handbook.—The publishers announce that this annual will be ready early in January, with carefully compiled lists corrected to December, 1889, and the usual tables relating to dynamos, arc and incandescent lamps, batteries, &c.

Margate and Westgate Lighting.—The Municipal Electric Light and Power Corporation has given public notice of its intention to apply for a provisional order for lighting Margate, Westgate, and adjacent parishes.

Malvern Lighting.—At a committee meeting of the Malvern Local Board, on Saturday last, it was decided to take steps with a view to obtaining powers for the supply of electricity for public lighting, &c.

Electrical Supply for St. Helens.—The St. Helens Town Council is about to take measures to apply for a provisional order for supplying electricity in the districts within the area of the gas supply of the corporation.

The Nile Steamers.—An addition has been made to Messrs. Cook's fleet of passenger steamers by the launch of a new boat, *Ramases the Great*. She is lighted with electric lamps.

Keeping with the Times.—Says the *Hastings News*: "The Town Council intends to light the whole front line, from end to end, with the electric light. It is a step which deserves the hearty commendation of all the ratepayers. The sea front is our harvest field."

How Money is Wasted.—The height of absurdity to which invention can be carried is well illustrated by the following extract from a patent specification recently published:—"The object of my invention is the arrangement of circuits for electric lighting in such manner that, with the same quantity of electricity, a greater number of lights may be fed than before, or the same number of lights as before with a smaller quantity of electricity. I base upon the principle that the eye will retain the impression of a strong light for a short space of time even after the light has been extinguished. Consequently, if a strong light be interrupted in quick succession, these interruptions will not be perceived if they are quick enough. Thus, if an electric light is interrupted 15 times and more in one second the eye fails to notice the interruptions, and will see the light as a continuous one. Supposing an electric circuit, the current of which is just strong enough to feed one electric light, was fitted with two such lights instead of one, and the current was passed every fifteenth or twentieth of a second alternately to one and the other light, the two lights would, to the eye of the observer, appear to burn continuously, and have the same effect as two lights, whereas in reality the two lights would burn alternately." The idea is upon a par with a suggestion that the filament of an incandescent lamp should be kept in a state of vibration so as apparently to produce the effect of a broad surface of light, and thus proportionately increase the luminous effect.

Mining Institute of Scotland.—A meeting of this Institute was held on the 21st inst. in the Hall of the Institute, Hamilton. In connection with Mr. Smith's paper on "Lightning Entering Drumsmudden Pit Workings," a communication was read from Mr. J. B. Dalzell, narrating an occurrence during a thunderstorm in Italy, which he said favoured the possibility of a thunderstorm effecting an explosion of gas in pits. As a remedy he suggested that the base of the lightning conductor should be more than 10 or 11 yards from the pit shaft, more particularly where there are metal guides, pipes, or wire ropes. It should also be obligatory on owners of fiery mines to fit up a proper lightning conductor upon the pithead frame of each shaft in which wire ropes are in use or at which the pithead frame is of metal.

Quick Work.—The Cardiff *v.* Gloucester football match, played at the Welsh metropolis last Saturday week, was over at 4.45 p.m.; the result was telephoned by the Western Counties and South Wales Telephone Company, Limited, to Gloucester, reaching the company's offices in that city at 4.48 p.m.; and was in the *Citizen* office at 4.55 p.m., or ten minutes from the conclusion of the game!

Proposed Telephone Exchange at Taunton.—A movement is on foot at Taunton to establish a telephone exchange in the town. A meeting was held last week, under the presidency of the Mayor, to ascertain what support the telephone would receive in Taunton. Mr. H. F. Lewis, of the Western Counties and South Wales Telephone Company, attended, and gave full details regarding the movement. The idea of the exchange was favourably received by those present. It was decided that a canvass should be made, and afterwards another meeting should be called. The company is desirous of establishing an exchange in Taunton, preparatory to constructing a trunk line between Bristol and Plymouth.

The Electric Light for Dover.—The Mayor has given notice that he will hold a special meeting of the Town Council on the 17th December, to consider the question of obtaining powers for the Corporation to supply the electric light in Dover.

NEW COMPANY REGISTERED.

Oriental Association, Limited.—Capital £5,000, in £1 shares. Objects: To take over the business of refreshment contractor carried on by Sydney Parton at 16 and 17, Old Cavendish Street, under style of the Oriental Association. To carry on, at the same address, or elsewhere, in Middlesex, the business of an electric light company in all branches, and in particular to construct, lay down, and establish all necessary cables, wires, lines and accumulators, lamps and works, and to light streets, markets, theatres, and public and private places. Signatories (with 1 share each): C. W. C. Smith, 2, Princes Mansions, S.W.; S. Parton, 1, Wimpole Street; W. L. Loveridge, 55, Middleton Road, Dalston; W. M. Baker, 10, Gray's Inn Square; A. G. Morron, 66, Waterloo Bridge Road; W. A. McBean, 7, Pelham Road, Wimbledon. The signatories are to appoint the first directors, and the company in general meeting will determine remuneration. Registered 25th inst. by Montagu Scott and Baker, 10, Gray's Inn Square, W.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Exeter Electric Light Company, Limited.—An agreement of 19th inst., filed 21st inst., between this company and Laing, Wharton and Down Construction Syndicate, Limited, cites that the syndicate has supplied the company with apparatus and articles to the value of £982 10s., and a licence has been granted to use the Thomson-Houston system. Under previous agreements, the syndicate is entitled to an allotment of 133 fully-paid shares of £10 each, and these will therefore be allotted by the company.

Electricity Supply Corporation, Limited. — The statutory return of this company, made up to the 20th August, was filed on the 2nd September. The nominal capital is £100,000, divided into 9,900 ordinary and 100 founders' shares of £10 each. The only shares at present allotted are the seven subscribed for by the signatories to the memorandum and articles of association, and upon these no call has been made. Registered office, 4, Great Winchester Street.

Wolverhampton Electric Light and Power Company, Limited.—The statutory return of this company, made up to the 30th ult., was filed on the 1st inst. The nominal capital is £50,000 in £10 shares; 23 shares have been taken up, and the full amount has been called and paid thereon. Registered office, Lichfield Street, Wolverhampton.

Electric Trust, Limited.—The statutory return of this company, made up to the 9th ult., was filed on the 15th ult. The nominal capital is £60,000 in £10 shares. 1,600 shares are taken up, and £2 10s. per share has been called thereon. The calls paid amount to £3,500, and unpaid to £500. Registered office, Palace Chambers, Bridge Street, Westminster.

Series and General Electric Traction Company, Limited.—The statutory return of this company is made up to the 8th November. The nominal capital is £200,000, divided into 130,000 preferred and 70,000 ordinary shares of £1 each. 904 preferred shares have been taken up, but no call has yet been made.

Julien Electric Company, Limited.—The final winding up meeting of this company was held on the 21st inst., when an account was given as to the manner in which the winding up has been conducted, and the property of the company disposed of.

Westminster Electric Supply Corporation, Limited.—The first return filed since the company's registration on the 30th June, 1888, is made up to the 21st November of last year, and was registered on the 18th inst. The nominal capital is given as £100,000, in £5 shares, but only seven shares are recorded as taken up, and upon these no call had been made or paid.

Monte Video Telephone Company, Limited.—The annual return of this company, made up to the 31st ult., was filed on the 9th inst. The nominal capital is £220,000, divided into 29,000 preference and 15,000 ordinary shares of £5 each. The shares taken up are 27,000 preference and 15,000 ordinary, upon which the full amount has been called and paid, the paid up capital thus being £210,000.

Croydon Electric Supply Company, Limited.—The registered office of this company is situate at 7 and 8, Ironmonger Lane, E.C.

Lancashire and Cheshire House-to-House Electricity Company, Limited.—The registered office of this company is at 3, Cook Street, Liverpool.

CITY NOTES, REPORTS, MEETINGS, &c.

The Electric Construction Corporation.

An extraordinary general meeting was held yesterday at Winchester House, for the purpose of making certain alterations in the articles of association.

The Secretary having read the notice convening the meeting,

The Chairmain (Sir Douglas Fox) said the directors were exceedingly sorry to give them the trouble of coming there, but the committee of the Stock Exchange wanted certain alterations made in the articles of association. That was the whole business for transaction, but as they had an opportunity of meeting the shareholders, it might be interesting to know that since the last meeting all purchases comprising the corporation had been made; the general business of the corporation was proceeding in a manner thoroughly satisfactory.

The following were the chief alterations made, which were carried unanimously:—

"That the following article be added after Article 8: 'No part of the funds of the company shall be employed by the directors of the company in the purchase of the company's shares.'

"That Article 25 be amended by adding at the end of the article the words: 'No call shall exceed one-fourth of the nominal amount of a share, and two months at least shall intervene between the time appointed for the payment of one call, and that appointed for the payment of the next succeeding call (if any).'

"That Article 88 be amended by omitting the whole of the article, and inserting in lieu thereof the words: 'The qualification of a director shall be the holding of shares of the company of the nominal amount of £1,000. A first director may act before acquiring his qualification, but shall in any case acquire the same within one month from his appointment, and unless he shall do so he shall be deemed to have agreed to take the said shares from the company, and the same shall be forthwith allotted to him accordingly.'"

The Blackpool Electric Tramway Company.

The fifth annual meeting of this company was held in the Victoria Schools, Tyldesley Road, on Saturday. Mr. Richard Horsfall, C.E., F.S.I., Halifax (chairman), presided.

The chairman said that it was his pleasing duty to propose the adoption of the report, and he hoped and trusted, in fact, he was sure that it would meet with their approval. Dealing with the balance-sheet, he found that the capital and liabilities, and the property and assets, were much on the same lines as last year, with the exception that they

had invested in the New Zealand Bank the sum of £2,000, which was bearing them interest at the rate of 4½ per cent. The expenditure, they would find also, was very satisfactory, and compared very favourably with last year's expenditure. And the receipts they must congratulate themselves on, for the very good season they had had in Blackpool had enabled them to make out so good a balance-sheet. Unfortunately, in the fore part of the year, a lady fell from the top of one of their conveyances and was killed. They had contracted with the insurance company to meet with any accident of that kind. The insurance company and themselves were at variance as to the construction of the policy, and they had written off a sum of money to meet the cost of that accident, in case they should have to pay it. Mr. Cooper, solicitor, of Manchester, had their case in hand, and they were in hopes that the affair would be decided in their favour. If the money was not required it would come back to the shareholders next year. He might say that they had again reserved a sum of money to meet any extraordinary wear and tear either on the line or the engines and boilers, or the machinery. He hoped that the shareholders would allow them to carry the money proposed forward, and take it back next year if they did not need it. Then they had a balance of £231 5s. 10½d. Of course, if they got that this year they could not have it next. If they could go on and make it a paying concern at 7 per cent., when the lease was run out they would not only be able to return the shareholders 20s. in the £, but something more.

Mr. Jno. Hoyle seconded, and it was carried.

Messrs. T. H. Morris and John Oddie were re-elected directors, and Mr. J. D. Taylor was re-appointed auditor.

Brush Electrical Engineering Company, Limited.

A STATUTORY meeting was held at the Cannon Street Hotel on Monday last, Lord Thurlow in the chair.

The Secretary having read the notice convening the meeting,

The Chairman said the meeting was simply a statutory meeting held in conformity with the Act relating to companies. They knew the circumstances under which the company had been formed, and he had now the honour not only to address the shareholders of the Brush Company but also those of the Falcon and Australasian Companies. Referring to the constitution of the board, he said it consisted of the old Brush board, including a new member, the Duke of Marlborough, and representatives from the Falcon and Australasian Company. After issuing new shares they had replaced, without any difficulty, the £75,000 worth of debentures and property of the Anglo-American, with debentures of the newly amalgamated concern. The shares would be issued, in accordance with agreement, to the Australasian Company when their patents had been assigned. There had been some slight deviation from the original scheme. The taking of the Australasian plant was now optional matter, which would remain thus until the 1st January. Whether they would take over these depended on the report of Mr. Percy Sellon, who, returning from Australia, would have had opportunities of examining the plant. His (the chairman's) opinion was that a good deal of it would be obsolete. They were now entering upon a new era in the history of their company; there would be all the energy of a new company combined with the experience gained in previous undertakings, it would be their own fault if now a handsome dividend was not returned to the shareholders. With reference to the works at Loughborough the more they saw of them the greater their admiration. The branch of engineering previously carried on at these works had not been discontinued, as upon examination it was found to be a very remunerative one; the works were also admirably adapted for the special manufacture of motors and the various kinds of engines necessary in electric lighting. He drew a favourable augury from the rapid spread of electric lighting, not only in the metropolis, but in every part of great Britain and the civilised world, and to meet the probable great demand a vast quantity of machinery would be required, they would of necessity get their share of the manufacturing work. The actual work in hand at the present moment was more by a considerable quantity than they turned out during the whole of last year. This was being added to daily by fresh orders, and the only difficulty was to execute the orders fast enough. The works in Belvedere Road were fully occupied, and the works in the country were more than fully occupied, and, though it was not a desirable thing to turn orders away, he was sorry to say they had been occasionally compelled to do so during the last eight or ten weeks. They were, however, giving great attention to this difficulty, which he trusted would be solved satisfactorily.

After a few questions had been answered by the chairman, the proceedings terminated.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending November 22nd, 1889, amounted to £7,238.

The Western and Brazilian Telegraph Company, Limited. The traffic receipts for the week ending November 22nd, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £5,202.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

(*Continued from page 592.*)

The early part of curve of dynamo No. 460 was taken with the very greatest care. Only a few of the points are marked for clearness, as the curve passed evenly through them all. The usual concavity at the commencement is shown in a marked degree. The slow rise of this curve for low degrees of excitation seems to indicate a greater degree of hardness of the iron. All the curves approximate to the same form over that portion of their length which corresponds with the ordinary range of excitation.

Table B shows the conditions of running and general behaviour of the machines shortly after starting. Very little more time was allowed before the measurements were taken than was necessary for the lamps to assume a proper working condition. At times, however, the tests had to be postponed till the machinery attained its normal speed. It will be seen that the current in most cases was above 10 ampères.

In Table C the more important values given in Tables A and B are compared, and their differences, with their proper signs, are added, to enable the alterations which take place when the machines and lamps are heated, to be more readily detected.

The current in every case but one fell as the evening advanced. This reduction is mainly due to the increase in resistance (due to heat) of the shunt circuit in the lamps. The effect of this is to lessen the action of the fine wire in the differential coils and allow the carbons to be separated a little farther; that is, to increase the potential difference required at the terminals of the lamps.

In ten out of twelve of the arc machines tested, the commercial efficiency was found to increase with the reduction of current that took place from the above cause. In the other two machines the current and efficiency rose or fell together. A comparatively small increase of current above the normal is found to produce a sensible diminution in the efficiency. Hence in practical work it is important to ascertain the most efficient current to take from the machines, and see that it is always maintained at that value. The increase in the efficiency may be partially due to a reduction in the losses caused by Foucault currents in the armature and field magnets, brought about by an increase in the specific resistance of the metal by heat. The loss due to magnetic viscosity in the armature core may also be lessened by the same agency.

It will be seen that the average output of the machines is much about the same whether they are hot or cold.

Total output of 12 machines,	cold	199·42	electrical horse-power.
" "	hot	195·94	" "
Difference		3·48	" "

Total power absorbed at pulleys by 12 machines,	cold	279·77	H.P.
" " "	hot	261·11	"
Difference		18·66	"

The power absorbed by the machines is much less when they are hot: the total reduction in the twelve tested being 18·66, or 1·5 horse-power per machine, while the diminution in the output was little more than a quarter horse-power per machine. This fact accounts in some measure for the gradual increase in the speed of the engines (which has been previously mentioned) as the evening advanced, though the steam pressure and number of machines driven remained constant.

As there is no direct method of ascertaining the power absorbed by Foucault currents and magnetic viscosity while the machines are at work (the usual method being to find the value of all directly measurable quantities and subtract their sum from the total power absorbed by the machine, the balance being debited to the above causes), an attempt was made to find approximately the alteration in the magnitude of these losses corresponding with given variations in the total induction through the armature, by the following method:—

The dynamometer pulley was placed on the machine to be tested, the field magnets were arranged so that they could be separately excited by a variable current, and the commutator brushes were removed from the machine. The zero of the pulley was noted, and the machine then run at the normal speed, the deflection produced on the pulley indicating the power absorbed by mechanical friction. The field magnets were then gradually excited and simultaneous deflections on the ampèremeter and pulley noted, the speed of rotation of the armature being also taken. From the data thus obtained the curves on the diagram (fig. 2) were drawn.

It must not be forgotten that the value obtained for the waste power, corresponding with a given degree of field excitation, does not necessarily represent that which actually takes place when the machine is at work with the given degree of field excitation. The modifying influence of the current in the armature cannot well be estimated. The reduction produced by it in the total induction through the armature core would tend to lessen these losses. At the same time, the losses in both armature core and pole-pieces would be increased, owing to the forward rotation of the field by the armature current crowding up, as it were, the lines of force into a smaller space, so increasing the electromotive force of the induced currents, the value of which is always

$\frac{dn}{dt}$ Another source of difficulty in the Brush machine is the uncertainty of the effect produced by the great oscillation of the armature field (about 40°) owing to the small number of commutator segments. The curves shown on diagram 2 present some striking peculiarities.

The points from which the several curves start on the vertical line for c = 0 may be regarded as their respective origins. The power indicated by the portion of the ordinates below this point is due to mechanical friction, and is constant for all degrees of excitation of the field. The curves Nos. 462A and B were taken with the machine cold and hot respectively. It will be observed that less power is wastefully absorbed when the machine is hot than when cold, and that as the two curves start from the same point the difference is not due to mechanical causes. These curves show in the early part a very slow rise in the waste power for a given increment in the field excitation; but, as the excitation is increased, the lost power rises with an increasing rate. On the same diagram the curves marked Nos. 1,856A and B were taken with increasing and decreasing currents in the field coils respectively. By reference to Table C it will be seen that dynamo No. 1,856 is one of those in which the efficiency rises and falls

B.—EFFICIENCY OF BRUSH ARC DYNAMOS (No. 7L), COLD.

Description of Machine.			Maker's Number. Machine.	Maker's Number. Armature.	Mechanical Data. Time of Run. Hrs.	Time of Run. Mins.	Revolutions per Minute.	H.P. absorbed at Pulley.	Electrical Data. Current in amperes.	At Terminals. P.D. in volts.	At Terminals. E.H.P.	Commercial Efficiency. Per cent.	Mean. Per cent.
Solid Frame.	Armature Plates.	Thin.	457	N.T.A. 149	0	37	930	18·59	9·745	1,132·6	14·79	79·6	74·29
			924	N.T.A. 146	0	30	913	23·24	10·495	1,231·9	17·22	77·8	
			454	N.T.A. 143	0	10	920	22·74	10·127	1,204·2	16·34	71·85	
			460	157	0	30	930	22·47	9·3	1,295·3	16·14	71·82	
			462	...	0	12	930	24·57	10·313	1,251	17·29	70·37	
		Thick.	467	N.T.A. 184	0	15	930	25·8	10·423	1,232	17·22	66·74	66·74
Rail Pattern.	Armature Plates.	Thin.	1846	158	0	10	908	24·22	10·423	1,263·6	17·6	72·8	71·43
			1840	152	0	27	914	22 26	10·202	1,168·4	15·97	71·7	
			1849	161	0	25	934	25·59	10·239	1,303·2	17·88	69·8	
		Thick.	1843	N.T.A. 188	0	35	927	23·82	10·239	1,231·9	16·91	70·99	68·27
			1861	172	0	35	920	20·51	9·428	1,036·7	13·10	63·87	
			1856	167	0	28	917	26·96	10·495	1,341	18·86	69·95	

C.—ALTERATION IN EFFICIENCY.

Description of Machine.			Maker's Number.	Temp. Cent. F.M. Core. Cold.	Temp. Cent. F.M. Core. Hot.	Current. Cold.	Current. Hot.	Commercial Efficiency. Cold.	Commercial Efficiency. Hot.	Differences. Temperature.	Current.	Efficiency. Per cent.	Mean. Per cent.
Solid Frame.	Armature Plates.	Thin.	457	30·5°	60°	9·745	9 396	79·6	82	+ 29·5°	− ·347	+ 2·4	4·42
			924	...	...	10·494	9·899	77·8	81·9	...	− ·595	+ 4·1	
			454	29·4°	71·1°	10·127	9·705	71·85	74·9	+ 41·7°	− ·422	+ 3·05	
			460	38·8°	56·6°	9·3	10·1	71·82	72·17	+ 17·8°	+ ·8	+ ·35	
			462	32·2°	66·6°	10·313	9·731	70·37	82·56	+ 34·4°	− ·582	+ 12·19	
		Thick.	467	33·3°	68·2°	10·423	9·861	66·74	69·75	+ 34·9°	− ·562	+ 9·01	9·01
Rail Pattern.	Armature Plates.	Thin.	1846	...	...	10·423	9·988	72·8	74·7	...	− ·435	+ 1·9	6·0
			1840	...	...	10·202	9·783	71·7	82·8	...	− ·419	+ 11·1	
			1849	28·3°	65·16°	10·239	10·001	69·8	74·81	+ 36·86°	− ·238	+ 5·01	
		Thick.	1843	28·8°	47·1°	10·239	10·089	70·99	73 31	+ 18·3°	− ·15	+ 2·32	2·44
			1861	...	...	9·428	9·265	63·87	67·56	...	− ·168	+ 3·69	
			1856	40·5°	68·8°	10·495	10·129	69·95	68·65	+ 28·3°	− ·366	− 1·3	

D.—DISTRIBUTION OF ENERGY SUPPLIED TO ARC DYNAMOS (No. 7L).

Maker's Number.	Expressed in Watts. Accounted for. 1 Mechanical Friction.	2 C^2 R.	3 False Induction, &c.	4 Available at Terminals.	5 Total.	6 Absorbed at Pulley.	Not Accounted for. 7 6−5.	8 Per cent. of Total, 6.	Remarks.
1856	338 2	1.376·8	4,011	14,703	19,799	20,108	309	1·53	Machine cold.
460	458	1,029·2	2,720	12,046	16,253	16,765	512	3·05	
462	230	1,223	3,798·4	12,902	18,153	18,331	178	0·97	

E.

Machine. 1 Maker's Number.	2 Area of F.M. Core.	3 Ampère-Turns, F.M.	4 H.	5 B.	6 μ	Armature. 7 Number.	8 Area of Core.	9 Total Induction.	10 B.	Remarks.
1844	442	43,200	122·8	4,882	36·5	...	78 sq. cm.	2,158,000	27,666	Solid frame } Machine cold.
460	442	43,200	122·8	4,825	39·3	157	78 „	2,132,600	27,341	Solid frame
1849	442	43,200	122·8	4,647	37·8	161	78 „	2,054,000	26,333	Rail pattern
1840	442	43,200	122·8	4,692	38·2	152	78 „	2,073,700	26,586	Rail pattern

with the current in the circuit. The curve taken with an increasing current is the only one of interest. The early portion is peculiar, and I can see no satisfactory explanation of the peculiarity. From the point where the exciting current is 4 ampères the curve is nearly a straight line, which, if produced downwards, would pass through the origin. In this machine, then, the power absorbed, driving the armature (on open circuit) through the magnetic field, increases directly as the current at least

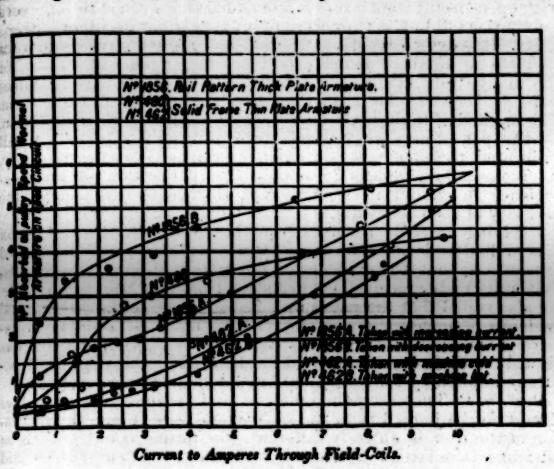


FIG. 2.

between the values c = 4 and c 10. But the power required to overcome mechanical friction is constant. Hence, if the resistance of the circuit remains constant, as it practically does in this case, the efficiency of the machine will rise and fall with the current taken from it. Curve No. 460 was taken from the other machine, in which the efficiency and current rise and fall together. The power absorbed by the armature on open circuit increases at first very rapidly with the current; but when the current has reached 3 ampères the rate of increase is not so

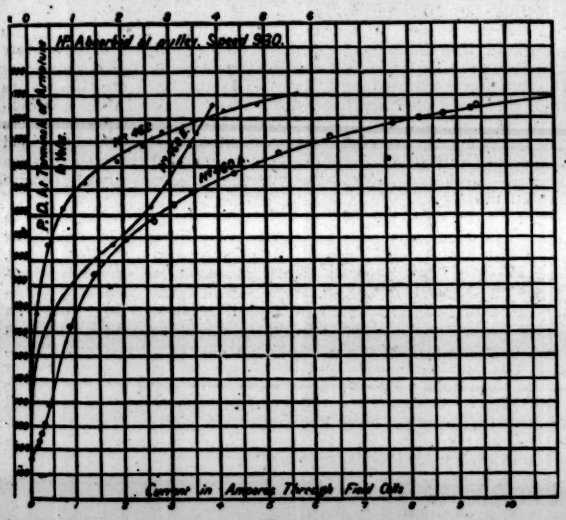


FIG. 3.

great, and it ultimately tends towards a small constant rate of increase.

The curves given in diagram 2 express the horse-power absorbed in driving the armature (on open circuit) through the variable magnetic field as a function of the exciting current. This method of representation is purely arbitrary, though convenient when it is simply desired to ascertain the alteration in the power absorbed for a given change in the exciting current.

The power required to drive the armature on open circuit through a magnetic field clearly will not depend on the value of the exciting current, but on the number of lines of force which the given excitation can force through the magnetic circuit of the machine. Those lines of force only which pass through the armature produce any useful effect. Consequently, if it is desired to ascertain the rate at which the lost power increases with the useful induction, the curves given in diagram 2 should be expressed as a function of the total induction through the armature.

The curves in diagram 1 may be taken as curves of induction through the armature, expressed as a function of the exciting current.

The curve of induction through the armature of dynamo No. 460 is shown in the diagram (fig. 3), and is marked No. 460a. The ordinates of curve No. 460a represent the power required to drive the armature (on open circuit) where the induction through it is proportional to the abscissa.

A similar curve from dynamo No. 462, in which the power wasted is also expressed as a function of the induction through the armature, is added for the sake of comparison. The same peculiarities which have been already noticed are now shown in a more marked degree. Curve 460a tends towards a constant ratio between the waste power and induction through the armature. In dynamo No. 462 the waste power increases enormously, with high values of induction through the armature.

The distribution of energy supplied to three of the machines is tabulated on Table D. The figures given in column 3 are taken from the ordinates corresponding to the given current on diagram 2. They do not necessarily represent the true value of the loss when a current is taken from the armature. The figures given in the other columns are the result of direct measurements while the machines were actually at work.

The data for the curves in diagram 2 were taken before the machines were started on their respective circuits; they would therefore be comparatively cool. For this reason the distribution of the power absorbed by the machines when cold was selected, so that the values from diagram 2 would be taken as nearly as possible under the same conditions.

It will be seen that the difference between the measured total and the sum of the energy absorbed in the circuit and various parts of the machine is very considerable, especially so in the case of dynamo No. 460. In all three cases the power absorbed at the pulley is greater than that which can be accounted for. Probably this difference is due to an increase in the power absorbed by useless induction when a current is taken from the armature.

In Table E a few approximate data are given with reference to the general condition of the magnetic circuit of these machines.

The values given were obtained with the armature running at the normal speed of 930 revolutions per minute on open circuit, the field magnets being separately excited. In columns 9 and 10 respectively, the total induction through the armatures, and corresponding values of B, are given. These and the dimensions constitute the only useful data. In columns 5 and 6 the corresponding values of B and μ for the field cores are given, assuming no leakage to exist. This, of course, is not the case. The figures simply indicate a low useful value of B in the field cores.

When the machines are generating a current all the values given will be altered. The actual value of B for the armature of dynamo No. 460 would be 23,028 when the machine is giving a mean current of 10·1 ampères.*

The effect of the fluctuations in the current given by the machines was observed by carefully measuring the current given by the machine and the potential difference at the terminals of the field coils; immediately afterwards the resistance of the field coils was taken.

The product of the measured resistance and current gives the potential difference requisite to maintain a steady current of the given value through the field coils. Subtracting this quantity from the potential difference actually measured, the remainder represents the mean E.M.F. due to self-induction.

Dynamo No. 460, hot.

(1)	Measured P.D. =	144·04 volts.
c = 11·09 ampères, R = 8·2 ω ∴ c R =		91·00 „
	Difference	53 „
(2)	Measured P.D. =	139·0 „
c = 9·82 ampères, R = 8·2 ω ∴ c R =		80·5 „
	Difference	58·5 „

Dynamo No. 460, cold.

(1)	Measured P.D. =	140·5 volts.
c = 11·33 ampères, R = 7·06 ω ∴ c R =		80·0 „
	Difference	60·5 „
(2)	Measured P.D. =	138·27 „
c = 10·85 ampères, R = 7·06 ω ∴ c R =		76·6 „
	Difference	61·67 „

From these data it appears that the current fluctuates about 1·5 per cent. on either side of the mean, or a total fluctuation of 3 per cent.

If the current were steady the gain in the field coils only would enable the machine to feed one extra lamp with the same armature speed; but the efficiency of the machine would not be much affected.

Of the Victoria Brush dynamos (No. E 2 used for incandescence lighting) only four were tested to ascertain their commercial efficiency.

Much more complete details of the behaviour of this class of machines are given in the various journals than can be found of the Brush arc dynamo. For this reason it was not considered worth while to multiply tests of the Victoria Brush machines.

* { Armature E.M.F. = terminal P.D. + c R + back E.M.F. in field coils = 1,220 + 126·25 + 57·2; Total = 1,403·45 volts. }

The method of testing was exactly similar to that used for the arc machines, excepting that both pistons in the dynamometer pulley were used, whereas in testing the arc machines only one piston was required.

VICTORIA DYNAMOS, HOT.

No. of Machine.	Current in ampères.	P.D. at Terminals, in volts.	$\frac{EC}{746}$	H.P. absorbed at Pulley.	Commercial Efficiency.
					Per cent.
1823 ...	192·96	108·49	26·06	36·28	77·34
1822 ...	236·66	106·85	33·89	41·82	81·03
1587 ...	90·013	97·66	11·78	17·71	66·52
1825 ...	246·2	110·6	36·5	42·33	86·2

The very small current taken from dynamo No. 1,587 will account for the low efficiency shown, as the losses are almost independent of the output.

As a whole, the efficiency of these machines is less than was expected.

To conclude. More complete tests, to ascertain the magnitude of the various losses which take place in the machines; the values of H, B, and μ, for both fields and armatures; the exact magnitude and form of the fluctuations in the current from the arc machines, and its effect in lessening the output from the machines, are much to be desired.

It would also have been instructive to have made a long series of tests obtaining data from which curves similar to those given in Diagrams II. and III. might be drawn, so ascertaining practicaly the law in accordance with which the power uselessly absorbed varies.

The very considerable difference in the efficiency of the various dynamos, working as nearly as possible under the same external conditions, and having to all appearance similar armatures, is apparent, and the question is, to what are these differences due?

It would seem that they must be caused by differences in construction, by which the deleterious reactions in the machines are altered; but if the tests which I have recorded in this paper could have been extended, and made under various conditions, some light would probably have been thrown on the point. The close agreement of the curves in Diagram I., and the great dissimilarity of those in Diagram II., seem to indicate differences in the quality or arrangement of the iron forming the armature cores.

There were no spare machines at the Exhibition, the whole number obtainable being in constant use; hence the tests made had to be confined to the shortest possible time, so that the lighting of the building should not be interfered with. This is the reason why further tests were not made, and also for the meagre and somewhat unsatisfactory nature of many of the data given.

Such as it is, however, I submit this paper to the members of the Institution of Electrical Engineers with the hope that there may be something in it which will draw forth remarks from some of them whose great experience makes anything they say valuable.

At the Spencer Street Railway Station, Melbourne, I have had for some years a small installation of about 60 Brush arc lamps at work lighting the station yard, and I am now arranging for a central lighting station from which about 800 arc and 4,000 to 5,000 incandescent lamps will be lighted. Thirty of the Brush arc dynamos used at the Exhibition have been purchased and will be utilised, most of them being fitted with new armatures, which I will have made upon lines that I hope, and believe, will prove satisfactory. At any rate, I will avoid the evident errors in construction of the armatures sent out from England with these machines.

If considered of sufficient interest, I will be glad at some future time to give the result of the work done, and also the details of some experiments made with a view to test the propriety of laminating the field magnet cores as well as the armatures.

NOVEMBER 14TH, 1889.

Abstract of Discussion.

Mr. MORDEY said the author was to be congratulated on the great care with which the investigations described in the paper had been carried out, particularly as no such tests had been previously made outside the manufactories. He thought, however, that Mr. Murray had given undue weight to the mechanical defects of the "thin plate" Brush armatures, for these defects were discovered at the Brush Works before the opening of the exhibition, and immediately remedied. Again, great stress was laid on the alleged fluctuations of the current from Brush dynamos. Some years ago when Profs. Ayrton and Perry described their "discontinuity meter" before the society, the speaker made tests on the currents in Brush arc circuits, but no discontinuity was perceived. More recently similar experiments have been made by passing the current through transformers, but no secondary E.M.F. could be detected. Referring to the effects of fluctuations described on slip 15 (of the proof), he could not see how the 3 per cent. variation was deduced from the numbers given, and as a possible explanation of the observed difference between the potential difference and the product, C, R, the speaker pointed out that if a perfectly steady current passed through the armature, the Pacinotti projections would induce currents in the field coils. The comparatively low efficiences of the Brush Victoria machines were probably owing to their being worked below their normal output.

Prof. AYRTON said he thought Mr. Mordey's inability to obtain evidence of discontinuity might arise from his using coils with iron cores and closed magnetic circuits, for in such apparatus very little effect is produced by small changes in the magnetising current. There was no doubt whatever that a great difference existed in the constancy of the currents from the Brush and Gramme machines used with the discontinuity meter.

Mr. MORDEY, in reply, said his 1882 (? 1883) tests were made with open circuit transformers, and added that even if the supposed fluctuations did exist they were of no very great disadvantage.

Mr. RAWORTH considered the efficiency tests gave results too variable to admit of much confidence being placed in them, for the many tests made at the Brush Works on various machines were so very regular that they had now ceased to make them. The method of taking the speed seemed open to serious objection, for the power may vary considerably during a minute. A well calibrated tachometer would have been much more satisfactory. As regards breakdowns from defective insulation, his own experience in exhibition work proved that leaky roofs cause the majority of such accidents.

Replying to some remarks from Mr. Raworth, Prof. AYRTON said he had no desire to disparage Brush machines, and only wished to point out that the evidence of fluctuation obtained by the discontinuity meter received confirmation from Mr. Murray's results. He also added that the paper under discussion contained internal evidence of imaginary accuracy, for to speak of ordinary commercial measuring instruments agreeing to $\frac{1}{100}$th per cent. was absurd; such instruments could not be read to the degree of accuracy implied by the statements made in the paper.

Prof. S. P. THOMPSON thought arc and incandescent machines should not be judged from the same standpoint, for as the saturation of the iron is entirely different, the former could not be as efficient as the latter. Referring to fluctuation of current, he said that the two kinds of arc machines in common use (viz., Brush and Thomson-Houston) had both few parts in the commutator and open coil armatures. The E.M.F. of such machines must fluctuate considerably, but the large self-induction of arc circuits tends to steady the current. His own experience, however, proved that small Brush machines give fluctuating currents, but he thought the currents from large dynamos working long arc circuits would be steadier. As an instance of the necessity for large self-induction in such machines, a case was quoted where a Thomson-Houston machine refused to do its work when the fields were separately excited. In concluding, the speaker said the relative values of magnetic force and permeability given on slip 14 were very disproportionate, and suspected they ought to be divided and multiplied by 10 respectively.

Mr. COUSENS said he had had considerable experience with arc plants in the Colonies, and had found the Brush machine very satisfactory. He had often noticed that the current decreased as the lighting continued, and that the lamps burn steadier as the time goes on. Cold weather, also, seemed favourable to steadiness. One of the chief mechanical defects he had experienced was the breaking of the commutator connections of shuttle-wound armatures, and when these were strengthened the wires on the armature broke. Of the latter phenomena he was unable to give an explanation.

Mr. ESSON, speaking of the efficiencies, hot and cold, given in Table C, said he was quite prepared for differences of 2 or 3 per cent., but not for 10 per cent., as in some cases is there shown. The value of the paper to electrical engineers would be considerably enhanced if the relation between the indicated horse-power of the engines and the useful electrical power had been given. His own experience with Phœnix dynamos driven from countershafting showed that with arc machines 66 per cent., and with incandescents 71 per cent. of the I.H.P. was available at the terminals. These proportions can be increased by belting the dynamos direct to the engines. In conclusion, he protested against the idea that open coil armatures were necessary for successful arc lighting, for ordinary gramme armatures had been made to give 1,500 volts satisfactorily.

Mr. KAPP considered the table of efficiencies very interesting, and thought they deserved careful study. From Table A the efficiencies of "thin plate" armatures were decidedly greater than those with thick plates, thus showing the advantages of lamination. The objections to the use of thin plates, viz., expense, weakness, and space wasted by insulation, were not insuperable, for the additional expense was not prohibitive, and he was glad to hear from Mr. Mordey that the defects of weakness had been satisfactorily overcome. As regards waste space, by insulation, he said that this need not exceed 8 per cent., and that some makers had ceased to use any insulation between the plates. Speaking of the fluctuation of current, he thought all agreed that the E.M.F. of Brush machines fluctuates, and the effect of self-induction was to reduce (not to destroy) the variations in the current.

Mr. ADDENBROOKE, who happened to be in Melbourne at the close of the Exhibition, gave an account of the general appearance of the installation, which he characterised as very neat. From what he heard, the lighting was considered very satisfactory, the arrangement in the picture galleries being particularly good. He was also informed that the transformer plants supplied by Messrs. Ganz and Co. and the Thomson-Houston Company, worked well. The boilers used were of a combined locomotive and marine type, with tubes and return flue, and the engines seemed to be an exact copy of Marshall's two cylinder high pressure type.

Mr. PREECE said Mr. Murray had entrusted him with the care of the paper, and he was sure its reception would be very gratifying to the author. He himself would have liked more information about

the behaviour of the arcs and the amount of illumination employed. Speaking of his own experience in exhibition lighting, he remarked that in determining the power necessary, he totally disregarded the nominal candle-power of the lamps, and based his estimate on the number of watts per square foot of floor space; as a matter of experience, he found half a watt per square foot gives brilliant illumination, and one-third of a watt was enough for most purposes.

Dr. HOPKINSON (who was in the chair), in confirmation of Mr. Mordey's and Mr. Raworth's statements, said that his tests showed the Victoria dynamo to be very satisfactory, the efficiency being 92 per cent.

SOME METHODS OF REGULATING ACCUMULATORS IN ELECTRIC LIGHTING.*

By GEORGE PRESCOTT, JUN.

(*Continued from page* 585.)

[IN last week's issue the drawings following fig. 3 were incorrectly designated, but the error is here corrected.]

The general arrangement of an accumulator plant consisting of two dynamos and two sets of batteries is illustrated in fig. 6, and a simple extension of this plan only is necessary to adapt any number of series of cells to a plant having any number of

FIG. 4.

dynamos. It will be seen that one equaliser circuit, and one charging circuit with its automatic cut-out, are common to all the dynamos that may be used. While this arrangement possesses all the flexibitity of the method of installing a single series of cells as shown in fig. 3, it has the additional advantage that at such times as the load is below normal, a spare dynamo can be exclusively employed for charging the cells, and thus avoid loss of energy in the pressure equaliser. As a general thing when the current equalisers, C, E, have once been adjusted at the beginning of a charge they need but little, if any, further attention, still if from any cause one series of cells should happen to be over discharged, or discharged more than the remaining series, a suitable readjustment of the current equalisers will permit the undercharged series to receive current at a higher rate than the others, and thus equalise itself with the others. It may also be mentioned that both the pressure and current equalisers may be made to operate automatically by the application of a potential magnet to the former and of a current magnet to the latter, together with a simple but somewhat expensive train of gears to move their levers. This is found to be wholly unnecessary in practice, however, as an engineer is usually in constant charge of such a plant while the dynamos are running, and he can easily devote the little time necessary to the infrequent regulation required.

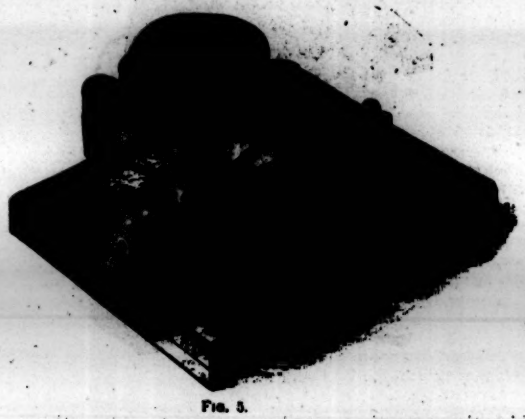


FIG. 5.

It was mentioned in the early part of this paper that it was possible to injure accumulators either by over-discharging them or working them at too high a rate. It is assumed that, in the larger plants, there will be such supervision available under ordinary working conditions that occurrences of this kind will be avoided; but a simple device for preventing such abuse of the cells is

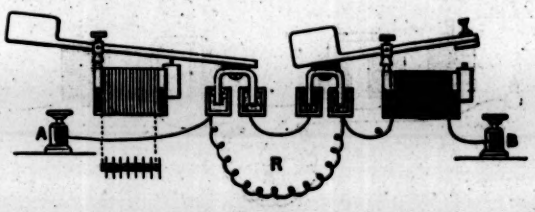


FIG. 7.

smaller plants, where such supervision is not always convenient, has been devised. It is called an overload and overdischarge switch, and its operation is based on the fact that, when a series of cells is overdischarged, their potential falls below a minimum value, and that when they are worked above their normal rate the current exceeds a maximum value. The apparatus consists essentially of a pressure magnet connected to the terminals of the battery, and of a current magnet in series with the battery; when the potential of the battery falls below a minimum value, the armature of the potential magnet is released and throws an artificial resistance into the battery circuit, and thus reduces the current; and similarly, when the current exceeds a maximum value, the armature of the current magnet is attracted and performs a similar function. The connections of this overload and overdischarge switch, C and F, are shown diagrammatically in fig. 7, in which a common resistance, R, serves for either magnet. The battery current passes from A to B through the overload magnet, while the terminals of the overdischarge magnet are, as before stated, in shunt to the battery terminals. In fig. 8 is illustrated a practical form of a combined overload and overdischarge switch.

With the object of reducing the cost of the regulating apparatus whenever both the combined overload and overdischarge

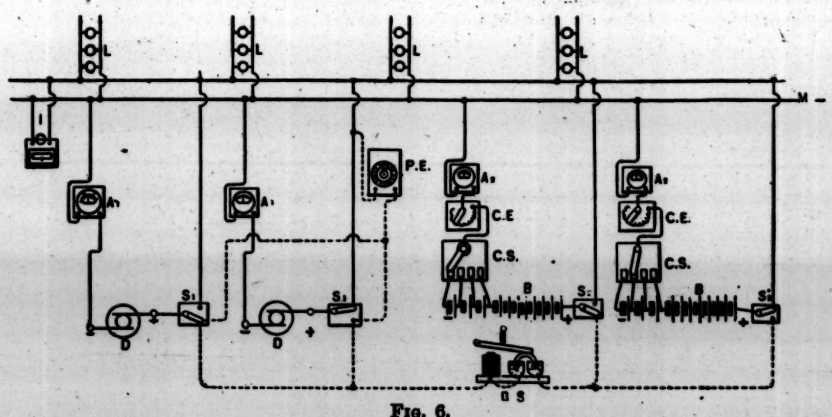


FIG. 6.

* Paper read before the American Institute of Electrical Engineers, New York, October 29th, 1889.

switch and the current equaliser are to be used with the same series of cells, the switch portion of the equaliser may be mounted on the resistance frame; and thus a single resistance coil be made to do service for both instruments. This combination, of

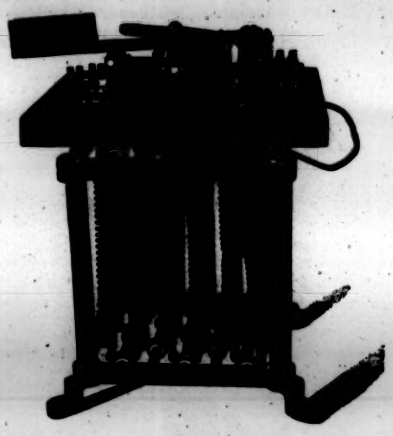


FIG. 8.

which the connections are shown in fig. 9, while allowing the current equaliser switch to control the full range of the resistance, at the same time causes the whole coil to be thrown into the battery circuit upon the operation of either the overload or over-discharge switch. This, of course, diminishes the brilliancy of the lamps, and thus indicates the state of affairs to those interested.

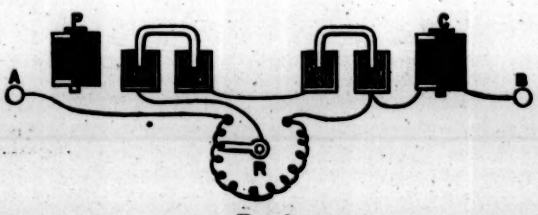


FIG. 9.

In applying accumulators to plants operated on the three-wire system, a simple extension of the method already described is adopted, except in the case of small stations requiring only one series of accumulators, and where the working circuits can be multiplied during the light load, so that the ordinary method will suffice. In larger plants the batteries are installed in pairs, each series having the same apparatus as before; and as this has already been fully explained, it will only be necessary to add that, in adapting two series of cells to the three-wire system, the two batteries are connected in series in the same manner that the dynamos are connected. The general plan of this arrangement is shown in fig. 10, from which unimportant details have been omitted. At the top of this diagram the three horizontal lines M (+), M (±), and M (−) represents the omnibus wires in the dynamo room, from which the feeders, L, are led. The three vertical lines, O (+), O (±), and O (−), are extensions to the omnibus wires to which the dynamos are directly connected in the usual manner when the levers of the switches, S_1, are on their upper contacts. The batteries are also connected with the omnibus wires in a similar way, so that when the switches, S_2, are closed on their lower contacts the batteries will also discharge into the lamp circuits in parallel with the dynamos. Now, if the switches, S_1, are turned to their lower contacts, and the switches, S_2, to their upper contacts, the current from the dynamos will divide at the switches, S_1, part going into the lamp circuits, and part through the batteries, which thus receive a charge. As in the multiple arc system, the potential of the dynamos being assumed to be raised above the normal to meet the requirements of the batteries, in order to suitably reduce the pressure on the lamp circuits, it is only necessary to adjust the resistance of the pressure equaliser, P, R. In central stations where the feeders are already provided with pressure equalisers the connections are still more simple, for the batteries are merely connected to the omnibus wires, while all other connections of the ordinary three-wire station are unchanged. In such cases, the increased pressure at which the dynamos are operated during the time the batteries are charging is reduced at the lamps to the proper point by the usual adjustment of the feeder or pressure equalisers. During the charging period all regulation of the accumulators may be dispensed with by opening the switch, S_1, when both batteries will be connected in a single series to the full pressure of both dynamos. In addition to the apparatus shown in the diagram, each series of cells is provided with a double plug switch and sockets suitably disposed, by means of which the relative positions of the batteries on the two sides of the system may be changed by simply transposing the plugs from one socket to the other. The object of this arrangement is to provide means for compensating for the unequal discharge of the batteries when the two sides of the lamp system are unbalanced; and the transposition is never made oftener than once each day. In all other respects the manipulation of accumulators when applied to three-wire systems is practically the same as when they are operated on the multiple arc plan. To increase the accumulator capacity of three-wire stations, double batteries are added in parallel to the first set, just as additional dynamos would be.

It was explained further back that the extra, or regulating cells, in each series often became charged sooner than the remainder of the cells, and required to be removed from the circuit before the others. This operation, of course, calls for some labour; and, little as it is, it would still be desirable to have the number of cells in a series remain fixed both during charge and discharge. By the use of what are called counter electromotive force cells, this result may be effected, and at the same time the pressure equaliser be dispensed with. These very simple cells are made like an ordinary Planté accumulator of plain sheets of an inoxidisable lead alloy and without active material. When a current is passed through them they act as gas voltameters, and while they instantly oppose a counter electromotive force of about two volts, they are incapable of producing a current of any appreciable amount or duration on account of their inoxidisable property. The use of counter electromotive force cells in place of equalisers is advantageous in several ways, for not only may their internal resistance be made so small as to be practically negligible, but their counter electromotive force is as effectual in reducing excessive pressure as a dead wire resistance, while possessing the unequalled advantage that the fall in potential of the current passing through them is unaffected by any variation in the strength of such current.

The method of using these counter electromotive force cells is shown in fig. 11, which represents a single series of accumulators installed in connection with a direct lighting plant operating one dynamo, as first described, and for simplicity and effectiveness this method cannot be well exceeded. The dynamo is connected to the lamp mains, as before, through an ammeter on one side, and through the upper contact of a two-way switch, S, on the other; while the battery, B, is similarly connected to the lamp mains on one side, but on the other the circuit is completed through several counter electromotive force cells, K_1, the number opposed being governed by the position of the cell-regulating switch, C, S. When the lever of switch S is on its lower contact, the charging circuit is completed in the now familiar manner. The action of a plant arranged in the above way is as follows:—assuming the lever of the cell-regulating switch to be turned off, or open, as the expression goes, and that the dynamo switch is on its upper contact, the dynamo alone supplies current to the lamp circuits. If, now, the lever of the cell-regulating switch is turned to its left hand contact plate, the battery will be similarly supplying current to the lamp circuits in conjunction with the dynamo, or alone if

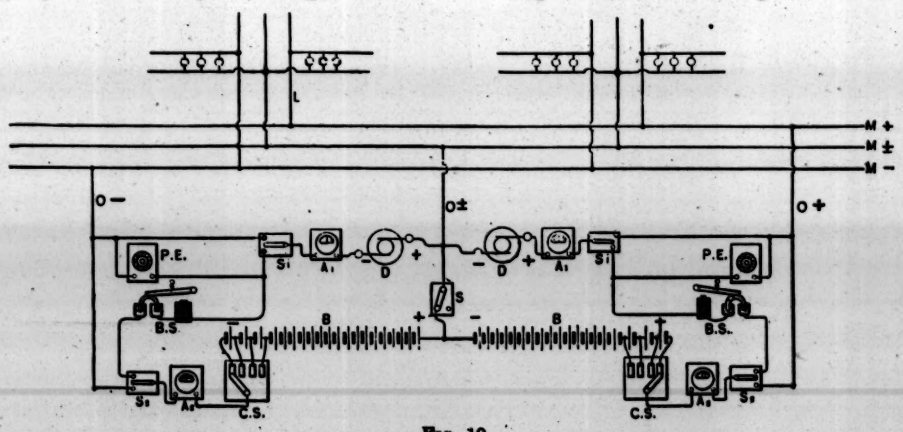


FIG. 10.

the dynamo switch is opened. If the dynamo switch is now turned to its lower contact, the dynamo current will divide at the point where it connects between the battery and counter electromotive force cells, part going through the battery and back to the dynamo through the (—) lamp main, while the remainder will pass through the counter electromotive force cells to the lamps. Thus, while the full pressure of the dynamo current will be effective at the battery terminals, its pressure at the lamps will be less by 2, 4, 6, &c., volts, according as 1, 2, 3, &c., counter electromotive force cells are opposed to the passage of the current into the lamps by the position of the lever of the cell-regulating switch.

When the battery has been fully charged and it is desired to stop the dynamo, the latter may be disconnected by opening the switch, s_1, when the battery alone will maintain the lamps. As previously explained, the potential of the battery will be a maximum immediately after it has received a charge, so that in this case if the battery has the usual allowance of extra cells its potential will be higher than the lamps require. More or less of the counter E.M.F. cells may now be inserted in the lamp circuit, however, until the potential is suitably adjusted. Although during the greater part of the discharge the E.M.F. of the battery will remain fairly constant, if discharged to its limit the potential will slowly fall towards the end, and this fall must be compensated for by removing one or more of the counter E.M.F. cells from the lamp circuit.

It is to be noted that by means of the above method, the number of cells in the battery proper is fixed and unalterable during both the charge and discharge, and that whenever the dynamo is supplying current to the lamps, its surplus current is always available for charging the battery; moreover, only one adjustment of the counter E.M.F. regulating cells opposed to the lamp current will be required. It is obvious that counter E.M.F. cells may be substituted with equal effectiveness for the equalisers and regulating cells employed in all of the previously described systems, and it seems unnecessary to go into any further particulars in order to illustrate the practicability of such systems when properly installed and operated.

We have now to consider another branch of the electric lighting business, in which accumulators also claim a share of attention, viz.: the supplying of current to lamps located at a considerable distance from the source of power.

The first method to be considered, is known as the half direct plan, in which one or more series of cells are installed in any number of sub-stations conveniently located near centres of lamp consumption. The charging station may be situated wherever economy dictates, without any special reference to the location of the batteries, for although the expense of the charging wire and the cost of the energy wasted in it cannot be neglected, both these factors must be offset by the saving effected from locating the power station in the most desirable situation. This half direct system is so called because during the period of maximum load half the current is supplied by the charging dynamo, and half by the batteries. At other times the dynamo may be simultaneously charging the batteries and supplying lamps, or the battery alone may be in operation. Each sub-battery station is, in fact, a small central station by itself, and it may contain one or several series of cells, the number, of course, depending upon the amount of lighting to be done in its vicinity. A common charging main, like an arc light circuit, passes through each sub-station, and each battery may be inserted in the main or withdrawn from it at will, exactly as arc lamps are cut in and out of circuit. The charging dynamo is usually of high voltage and of moderate current capacity; machines of 500 volts and 15 ampères to 1,300 volts and 40 ampères may be employed in small stations, while in larger ones the latter machines and their circuits may be multiplied. For charging purposes shunt wound dynamos are preferable on account of their non-reversibility, but even series and compound-wound machines may be used if suitable precautions are taken. The arrangement of the accumulators and regulating apparatus in each sub-station on the half direct system is essentially the same as the method adopted in the last described multiple arc system. The connections of two sub-stations installed on this plan are shown in fig. 12, in which station one is shown with its switches in position for both its battery and lamp circuits to receive current from the charging circuit; while station 2 is disconnected from the charging line, which is closed outside of it, and the batteries alone supply the lamp circuits. The switch which is employed to throw the batteries into and out of the charging circuit is of the snap action type, and is sometimes called a consumer's switch. It maintains the integrity of the charging circuit when the batteries are removed from it, and provided with a spark coil which prevents the opening of the charging line and the consequent formation of the injurious arc which results on the interruption of high potential circuits. A modified practical form of this switch is illustrated in fig. 13. As shown diagrammatically in the sketch, it consists, in the main, of four terminal contact springs which bear against an insulated cylinder in which are imbedded two rows of metallic contact strips. In one position the two left hand and the two right hand springs are brought into electrical contact, but if the cylinder is rotated slightly the two middle springs will be brought into electrical contact, while the two outer ones are left free, as shown respectively at n and n_1. As before stated, this change is effected rapidly and without breaking the circuits. These switches are usually operated by hand at the beginning and end of a charge, at which time whatever inspection of the cells is necessary is also generally made. By applying the polarised magnet principle to this switch it can be made to operate automatically from the central station through a momentary

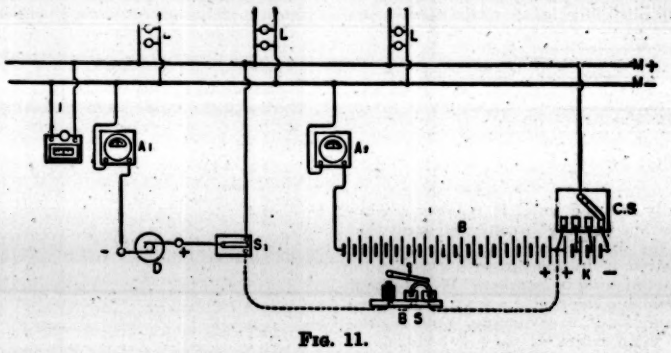


FIG. 11.

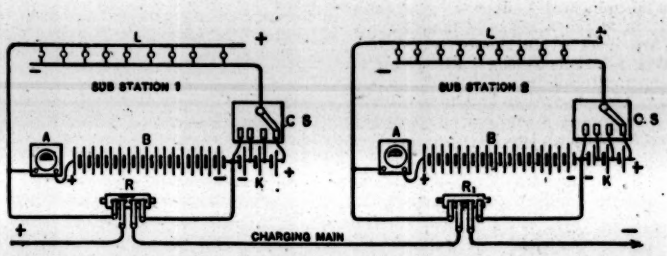


FIG. 12.

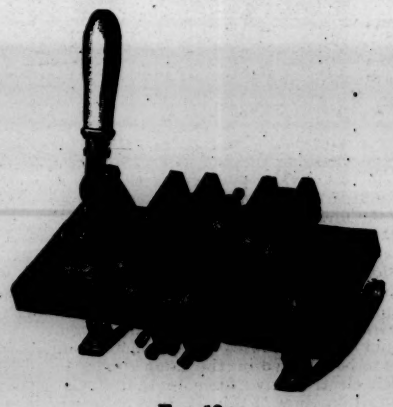


FIG. 13.

reversal of the charging current, a principle which has already been applied.

While the method just described of locating the batteries in sub-stations near the lamps to be supplied, reduces the resistance of the supply wires to such an extent that the variation of potential with changes in current strength is unimportant compared with what it would be were all the lamps operated from one central point, under ordinary conditions, still a similar variation does occur from a different cause. We have already seen that the potential of a battery is higher while it is being charged than at other times, and that the greater the charging current the higher the potential of the battery becomes. It is evident that if charging commences when only a very few lamps are burning in a given battery, only a small part of the charging current will be required by the lamps, while the greater part will pass through the battery. This will raise the potential of the battery considerably, and as the lamp mains are permanently connected to its terminals, the lamps will receive an excessive pressure. As the number of lamps increases, however, more of the charging current will pass to them and less through the battery, the potential of

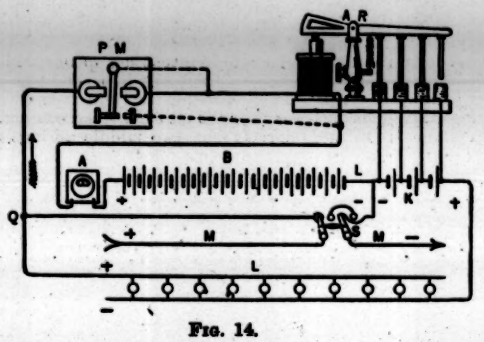


FIG. 14.

which thus becomes gradually reduced until it reaches a minimum, when the number of lamps burning becomes so great that the whole output from both the dynamo and battery is required to maintain them. The variation is in the opposite direction, of course, when the lights are diminishing in number. It is evident from the preceding facts that during the period when the charging dynamo is running and the lamp loads are varying, some regulation of the pressure at the lamp mains at each sub-station is required. This regulation is automatically effected by means of the apparatus shown in fig. 14, in which a solenoid magnet, A, B, and a polarised magnet, P, M, are inserted in the battery circuit. In all other respects the relative positions of the battery, lamps, and charging circuits remain unaltered from the arrangement shown in the last diagram. The operation of the apparatus in this sub-station will be as follows:—Assuming the charging dynamo to be delivering a current through the charging main, M,

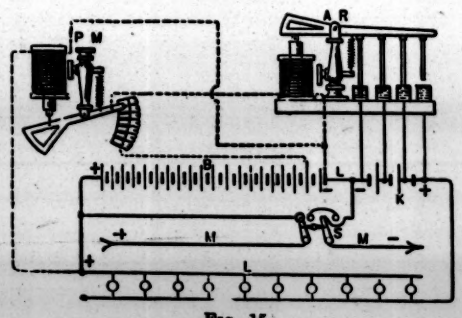


FIG. 15.

and that the consumer's switch is in the position shown in the diagram, the charging current will pass from M (+) to the point Q, where it will divide, part going through the lamps and the opposed counter electromotive force cells, K, to the point L, and thence to the line again, the remaining part of the current passing from point Q through the magnets, P, M, and A, B, and out through the battery to point L and line. When the current is flowing in the direction of the arrow, as in the case just cited, the armature of the polarised magnet is moved to its left hand contact as shown, and the plunger of the solenoid magnet is more or less drawn down, according to the strength of the current. This action of the solenoid magnet causes one or more counter electromotive force cells to be inserted in the lamp circuit in such a way as to oppose their electromotive force to that of the charging current, while the full pressure of this current is available at the battery terminals. If now the number of lamps is increased to such an extent that not only all of the charging current passes through them, but also that more or less current from the battery joins in parallel with it; then the current from the battery will traverse the polarised magnet in the opposite direction from that previously taken by the charging current, and its armature will be moved against its right hand contact, thus short circuiting the solenoid magnet and the counter electromotive force cells, as indicated by the broken line. For, as the sketch shows, the lever of the solenoid magnet is so balanced that when no current is traversing the magnet, its metallic contact rods all dip into their respective mercury cups, and so shunt around the counter electromotive force cells with which the latter are in electrical connection. When the lamp load becomes reduced and the charging current is discontinued either by the stoppage of the dynamo, or by its being shunted past that particular battery by a movement of the switche s to the right, the battery alone works into the lamp circuit, and the counter electromotive force cells are short circuited.

While the automatic regulator just described, when applied to the half direct system, maintains the pressure at the lamps sufficiently uniform for practical purposes, whether the charging dynamo is operating or not, and although the proximity of the battery to the lamps it supplies prevents undue variation of potential when the load changes; yet a perfectly automatic method of maintaining a constant potential at the lamp circuits, even where the resistance of the leads is great, would be generally useful. Such a method is illustrated in fig. 15, in which the battery, counter electromotive force cells, lamps and charging circuits occupy the same relative positions as before. The solenoid magnet of the regulator is no longer in series with the battery, however, and is, in fact, entirely disconnected from it, while the polarised magnet is replaced by a second solenoid magnet, P, M, wound to high resistance. The armature lever of this second solenoid is so mounted that when its core is attracted or released this lever moves over a series of contact strips which are insulated from each other. Connected with these contact strips are coils of wire of suitable resistance, the whole constituting a simple rheostat, more or less of the wire of which is included in a local circuit, according to the position of the lever which acts as a movable contact. The solenoid magnet of the regulator, A, B, and one or two cells of accumulators are also included in the local circuit referred to, the strength of the current flowing in this circuit depending upon the amount of resistance inserted by the movement of the lever of the pressure magnet, P, M. The latter magnet is connected directly with the battery terminals, and as the potential of the battery rises and falls the current flowing through this magnet varies correspondingly, causing a similar variation in the current in the local circuit. Thus an increase of pressure at the lamps, which are connected to the battery terminals, indirectly causes the armature of the regulating magnet, A, B, to be attracted, and this in turn opposes one or more counter electromotive force cells in the lamp circuit until the pressure again becomes normal. If the pressure at the lamps falls below normal the regulator acts in the reverse way, cutting out the counter electromotive force cells until the normal pressure is again restored. If in connection with this method the polarised consumer's switch, previously mentioned, is substituted at S, the operation of such a sub-station will be entirely automatic.

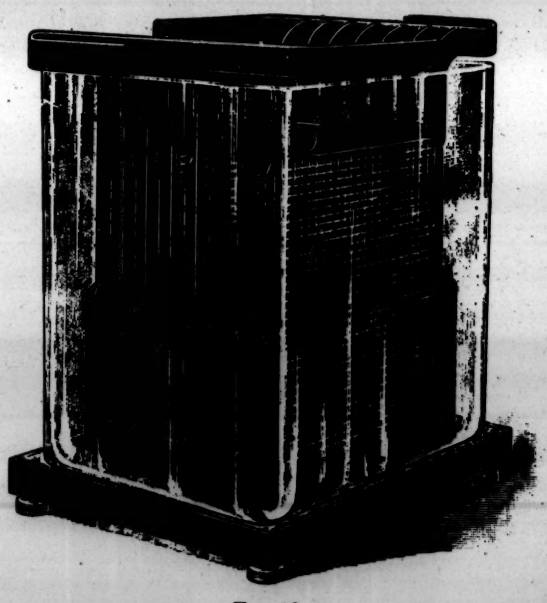


FIG. 16.

It is proper to mention that the pressure magnet must be very sensitive and requires a delicate adjustment, besides being somewhat costly on account of the excellence of the workmanship required. Although I have only seen the instrument used in an experimental way, its practical application to similar purposes has given satisfactory revults.

Under certain circumstances, as, for example, when a lighting station is worked to its full capacity at night, but during the daytime has ample surplus power, the all-accumulator system may often be applied to increase the capacity of such a station with satisfactory

results. For such cases the sub-stations of accumulators are located at distant points in the usual way, the cells being charged during the day and discharged on the lamp circuits at night while the power plant is doing its regular work. The arrangement of the accumulators and regulating apparatus in the sub-stations of the all-accumulator system is practically the same as when the half direct system is employed, except that a simple transfer switch which transfers the battery from the lamp circuit to the charging circuit, and *vice versa*, is used instead of the consumer's switch.

It is needless to say that all of the methods which have been described of employing accumulators in long-distance lighting may be adapted to existing lighting plants, and that when so adapted the earning capacity of such stations may be considerably increased without extending the capacity of the power plant. For this purpose there will usually be required a special dynamo at the central station, a charging circuit taking in the territory outside of the regular lighting limits, and one or more sub-stations with accumulators.

There are, of course, numerous other ways of utilising accumulators in central station supply systems, such, for example, as the double battery method now operated in England by the Electrical Power Storage Company, in which the dynamos are kept running for 24 hours daily, duplicate sets of accumulators being alternately inserted in the charging and supply circuits at uniform intervals of time, by an automatic mechanical device. But I have limited this paper to a description of some of the simpler methods of accumulator regulation which may be readily adapted to ordinary lighting plants, and, in concluding, can only hope that I have succeeded to some extent, at least, in showing that when so applied in an intelligent manner, accumulators do occupy a useful place in the industry of electric lighting.

Through the courtesy of the Electrical Accumulator Company, I am enabled to present to the Institute this evening the first proofs of some cuts of a new line of standard accumulators recently brought out by that company. One of the cells referred to is shown in fig. 16, and the dimensions and capacities are descibed in the following table :—

LIST OF ELECTRICAL ACCUMULATOR COMPANY'S STANDARD CELLS.

(*Approximate data.*)

Figure.	Type of cells.	Charging current.	Working rate and capacity. Ampères.				External dimensions of jars. Inches.						Weight of acid. Lbs.		Weight complete cell. Lbs.		Height over all including connections.
		Normal.	Normal.		Maximum.		Glass.			Rubber.							
		Ampères.	Rate.	Amp. hrs.	Rate.	Amp. hrs.	Length.	Width.	Height.	Length.	Width.	Height.	Glass.	Rubber.	Glass.	Rubber.	Inches.
16	15 L	15 to 30	30	300	40	250	10¾	12¼	13¾	...	...	...	50	...	130	...	15¾
	23 M	10 to 25	25	150	30	110	10¼	8¼	9¾	6¾	7¼	9 7/16	16	11	50	40	11¼
	15 M	5 to 15	15	100	20	70	7¾	8¼	9¾	4¾	7¼	9 7/16	11	7	35	25	11¼
	7 M	2 to 6	6	40	8	25	4¾	8¼	9¾	2¾	7¼	9 7/16	6	3½	20	13	11¼
	5 S	1 to 2	2	8	3	6	...	...	...	1¾	3¾	6 9/16	...	½	...	2½	7

Electromotive force of each cell is about 2 volts.

NEW PATENTS—1889.

17930 "Improvements in incandescent electric lamps." J. H. TUCKER. Dated November 11.

17974. "Improvements in apparatus for welding by aid of electricity, which improvements are also applicable for other purposes." H. H. LAKE. (Communicated by H. Lemp, United States.) Dated November 11.

18005. "Improvements in electro-magnets for electric signalling apparatus. G. BOWRON. Dated November 12.

18010. "Improvements in lamp fittings for electric lighting." I. A. TIMMIS. Dated November 12. (*Complete.*)

18018. "Improvements in electro-magnetic brake and traction increasing system." A. J. BOULT. (Communicated by E. E. Ries and A. H. Henderson, United States.) Dated November 12. (*Complete.*)

18028. "Improvements in moulding plates for electric accumulators." E. DE PASS. (Communicated by La Société Jacquet Frères, France.) Dated November 12.

18051. "Improvements in and relating to electric signalling apparatus, chiefly designed for use in hotels and other buildings. H. H. LAKE. (Communicated by F. E. Morgan, United States.) Dated November 12. (*Complete.*)

18067. "Improvements in the manufacture of secondary batteries or accumulators." A. B. CUNNINGHAM. Dated November 12.

18159. "Improvements in electric contact apparatus." C. WEUSTE. Dated November 13.

18172. "Improvements in China or porcelain electric light fittings." J. H. TUCKER. Dated November 14.

18220. "Impsovements in electrical signalling apparatus for railways." H. KIRCHMANN. Dated November 14.

18261. "Improvements in and relating to the construction of joints for telegraphic, telephonic, and like wires." E. J. H. RASTRICK. Dated November 15.

18340. "Improved means of insulating electric conductors." R. PUNSHON, A. H. MILLER and W. MUIR. Dated November 16.

18343. "Improved safety apparatus for a network of multiple electrical conductors." SIEMENS BROS. & CO., LIMITED. (Communicated by the firm of Siemens and Halske, Germany.) Dated November 16.

18355. "Improvements in secondary generators, transformers, or converters of electricity." J. D. GIBBS and E. FRIQUET. Dated November 16.

18361. "Improvements in electric meters." S. Z. DE FERRANTI. Dated November 16.

18362. "Improvements in electric locomotives and other variable speed electric motors." S. Z. DE FERRANTI. Dated November 16.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888.

16471. "Improved means or apparatus for reversing and regulating the brushes of dynamo-electric machines, partly applicable to electric motors." J. S. RAWORTH. Dated November 13. 11d. One or more pairs of brushes are carried by spindles or shafts projecting from a rocking frame or lever. Each of these spindles or shafts is provided with a small crank or lever arm having a projecting pin, and springs or weights are provided to keep the rocking frame and the spindles carrying the brushes in a middle or central position. A fan driven by the dynamo spindle, and provided with radial vanes or blades, is arranged to revolve in a casing also provided with vanes or blades, and filled with liquid. The fan, in revolving, tends to carry with it the casing which is supported in a bearing that permits of circular motion. A double ended lever in connection with the casing engages the pins carried by the hereinbefore mentioned crank or lever arms. When the dynamo commences to revolve in either direction, the fan, acting upon the liquid in the casing, causes the double ended lever in connection with such casing to overcome the action of the springs or weights which hold the brushes in the middle position, and to force the brushes into contact with the commutator and in proper position according to the direction of rotation of the dynamo. As the speed continues to increase, the double ended lever overcomes the action of the springs or weights, and carries the rocking frame or lever forward sufficiently to adjust the lead of the brushes corresponding to the increase of speed. 1 claim.

CORRESPONDENCE.

The Ziperaowsky Electric Tramway.

We have read in No. 625 of your esteemed Journal some observations relating to our electric tramway with vertical track, which induce us to reply as follows :—

You remark, in the first place, that the manufacturing expenses of a tram line made on this system must be very high, especially with regard to the extremely strong construction of the channel, owing to the strong side thrust. We beg to remark in this point that this

side thrust does not exclusively and directly act on the masonry channel; it acts also on the strong iron sleepers in the channel, that will oppose, at all events, a sufficient resistance to the thrust.

As relates to the supposed expensiveness of such a tram line, we will soon be in a state to dispose of concrete facts, as we actually made, on our own territory, a proof line on this system, for a distance of about one kilometre, with ascensions, curves and automatic points. We may already mention at present, however, that we have made very particular calculations on the probable manufacturing cost of this line, and found that it will be relatively less than those of a line with horizontal track, having two rails laying on the pavement, and, besides, a channel with underground conduits.

As a further deficiency you mention that an obstacle on the rails will cause the car to tumble on its side, or, at least, to jam itself tight. To this objection we beg to reply, that these dangers, arising from the now mentioned eventualities, are by no means greater in our tram line than in any other electric line with subterranean conduit; on the contrary, it is supposable that with tram lines on our system such hindrances can be much easier laid aside, as the construction of the fixed connection extending into the channel is much stronger than that of the conduits of other electric tramways with underground leads. By no means, however, can this be considered as a defect that would make the system unpractical, or that could not be prevented by precautionary measures of a sufficient security; and we may note, that by means of clearers and brooms, fixed on the cars, accidental obstacles on the lines will easily be removed.

You noted furthermore that the faculty of making the cars very narrow performs no peculiar advantage of this system, as this can be done with ordinary cars too. This we concede within certain limits. But with tram lines with vertical rails there is soon reached a track-width that will be impracticable, as an unequal inclination of the rails would cause a very unquiet movement.

In regard to the pavement we may note that the advantages, mentioned in the description, are effectively peculiar to our system, it being indicatable that by the falling out of the horizontal track there *must* be spared a respective part of pavement work.

You doubt whether specialists and tramway engineers will look with favour upon this system. We have pleasure in informing you that numerous specialists, tramway engineers, and delegates of local boards *have* visited and thoroughly studied the model of this tram line, shown at our factory, and *have* convinced themselves of the really important and practical advantages of our system.

We request you kindly to publish this reply in your esteemed Journal.

Ganz & Co.,

Eisengiesserei und Maschinen-Fabriks-Action-Gesellschaft in Ofen Electrotechnische Abtheilung.

Budapest, 22*nd November*, 1889.

Underground Mains.

Conduits for underground electrical conductors are generally supposed to facilitate the construction and repairs of an underground system, but such is not the case, as I will endeavour to show.

Nothing that is drawn in can long withstand the damp and confined atmosphere of a conduit, mixed as this air is with sewer and illuminating gases. If the conduits are made of wood, the acid coming from the wood itself contributes to the process of disintegration and decay.

When a cable or conductor in a conduits fails, in nine cases out of ten there are no cables or conductors ready to supply the place of the one pulled out, and it is necessary to wait for one to be manufactured.

This is the "draw in and draw out" system.

The Edison is different, and the conductor cannot be pulled out and replaced by another; but the fault, when it occurs, is local, and can be located to an inch, and remedied in as short or less time than it takes to get ready to pull a cable of 500 feet length out of a conduit.

The Edison Company in this city have located and removed or repaired over 300 faults, due to original bad construction rather than to the system itself.

By the laws governing the currents the defective spot is ascertained, the earth above it removed, and the cable or conductor repaired.

The manner of locating faults with such exactness is known as the "loop-test," and the process is well described in page 226 in Culley's hand book, eighth edition, and also by Kempe under the head of "Murray's loop-test," by which is found the sum of two resistances and their difference. Subtracting the difference from the sum, half of the remainder is the resistance of the shorter length; which again, deducted from the sum, gives the resistance of the longer length. The resistances are proportional to the lengths.

Faults in ocean cables are located by this means within a very few miles or fractions of a mile.

In ordinary city limits they are located within a few feet or fraction of a foot. When it comes to the distances between splice boxes or hand holes, the defect can be located to an inch.

A portable battery, galvanometer, and a modified form of Wheatstone bridge are used for this purpose.

The system with which I am identified is a draw in, but not a draw out system; for this reason there has been no occasion to draw out. If the insulation is impaired or destroyed it must be from mechanical means, such as breaking or injuring the wrought iron pipes, which is proof against an accidental blow of the picks.

The pipe is placed far enough below the surface of the ground not to be disturbed in ordinary street repairs.

The material within the pipe is hermetically sealed from such agencies as destroy gutta percha, india rubber or anything else that is of the vegetable kingdom.

The oil we use in a pipe is a pure distillate, and no product of distillation undergoes change except for the better, when confined in air-tight vessels. Thus there is no deleterious change.

As before stated, the Brooks method is not a draw out system, for the reason that there is no necessity. But a thousand feet of cable can be drawn out easier than five hundred feet could be drawn from any conduit system, because the former is lubricated inside the pipe.

If perchance the insulation becomes impaired, as stated, it must be from some damage done to the pipe, enough to expose the conductors, as a mere hole in the pipe will not admit moisture, because the oil is much heavier than water. The defect must be local, and its position can be readily determined as before explained, and a pipe cutter, with a few feet of cotton covered wire, can easily repair the damage.

On the other hand, when a fault is detected in a cable that has been drawn into a conduit, every portion of it shows serious disintegration.

If a cable of our system is injured by mechanical means, the surface of the ground must be disturbed, which would be enough to indicate the exact spot of the "trouble" without the aid of the "loop-test."

The effect of confined air, such as contained in a conduit, has been known in England for at least 30 years.

A patent was taken out to preserve the gutta-percha covering on conductors by drawing the cables into iron pipes filled with water.

The English Post Office Department do this yet wherever it is practicable.

Johnson and Phillips adopted this plan in laying their mains for electric light installations until latterly; now they insulate with oil.

Telephone exchanges require large numbers of conductors of small diameter. Five hundred of these conductors, properly insulated, can be drawn into a 3-inch diameter pipe, when oil is used. These conductors

generally take one direction in getting from the basement of the exchange into the street. Suppose for that purpose a single pipe of large diameter is used, for instance, one of 15 inches. The ends of the pipe bent upwards, in order to prevent the loss of oil. This pipe would have a capacity for 10,000 conductors, which could be drawn into the oil in groups of one hundred. I know of no method by which the insulation could be so well preserved.

Now, compare the cost of such an arrangement with the conduit system that has been in process of construction for the last six months, which when finished will be only a place for the reception of the conductors. Ten times as much money is spent in making a poor job as is necessary to make a good one.

When once in the street, the conductors would diverge and take opposite directions. Then two or more pipes of smaller dimensions could be used. Such a plan could be adopted as would accommodate the number of wires as they diverge in different directions.

Again compare the cost of such an arrangement with that of some of the subways that have been constructed in New York City.

Philadelphia has more electrical conduits than all the other cities of the United States. There are as many as four in some of the streets. There are, however, very few conductors in them, but a new industry has been developed, that of keeping the subways in repair, pumping water from the manholes, cleaning the ducts from the dregs of the sewers that have been broken open and their contents deposited in the ducts and manholes.

In some cases the water mains have broken and filled the conduits with water, producing wash-outs and caving-in of street pavements. Rotating fans are used to clear the conduits of the explosive gases, which also produce death by suffocation, nearly as instantaneous as that produced by the arc light currents in New York.

We have had over fifty explosions in Philadelphia; I have this on the authority of one of our best posted electric light engineers. Most of our conduits are made of wood, and the explosions as terrific and stunning manifestations do not reach the magnitude of some that have occurred in Broadway, New York, where, according to the reports in the New York papers, a cast iron manhole cover, weighing 300 lbs., was thrown over a four-story building. The ducts of these conduits are made of wrought iron.

Conduits are expensive, and their construction a slow process, which interferes with the use of the streets. Large quantities of earth have to be carted away.

With the Brooks system the iron pipe occupies so small a space, that all the earth taken out is repacked in the trench. Ten thousand feet of trench have been opened, the pipe laid, the trench closed, repaved, and cables drawn in between 7 in the morning and 6 o'clock in the afternoon of the same day, and no patching or leveling up of pavement required afterwards.

It is stated that in laying conduits extra ducts can be provided for future growth of business.

By the Brooks system extra conductors, or a cable containing more conductors than required by the present need, can be drawn in by the one operation.

By the Brooks system there are no vacant spaces for the collection of explosive and deleterious gases.

In proof of this article it goes for something that the cable I laid for the Pennsylvania Railroad Company, containing 53 conductors, has worked for nearly three years without a moment's interruption to any of the conductors, although connected to overhead wires running to New York, Pittsburgh, and Washington.

There has been no expense for repairs and maintenance except to paint that portion of the pipe running over the Schuylkill bridge and along the elevated railway.

I especially draw the attention of my friends here who have been so industrious during this time drawing out cables from conduits and repairing the conduits themselves.

D. Brooks.

Philadelphia, *November 15th.*

Teachers and Students.

I have no desire to prolong the discussion on the above, but there are points in Prof. Ayrton's letter which I feel need correction. I never implied Prof. Ayrton was personally responsible for the suppression of a speech made by me during the discussion on Mr. Preece's paper on Lightning and Lightning Conductors, and to which no exception *whatever* was taken at the time I made it. I said I presumed it had been suppressed by the editing committee; the inference I wished to convey was that it would come officially under the purview of the chairman of the committee. Prof. Ayrton's memory must be at fault when he tells your readers he had not at that period returned from Japan, for he was not only present at the Society of Telegraph Engineers, but he himself opened the discussion on the evening I spoke, viz., December 11th, 1872.

There must have been a committee of some sort responsible for the publication of the Society's proceedings; who they were is a matter of small moment, but the fact that a speech I suppose considered inconvenient to an interest having influence on the council *was* suppressed is a matter of serious moment, which Prof. Ayrton would seem to have found it convenient not to make any comment upon.

After the meeting was over Mr. Culley, the then Chief Engineer of the Postal Telegraphs, asked me to call upon him to discuss the matters on which I had spoken, and I called upon him by appointment on the next day, December 12th, 1872.

To my surprise I found Mr. Culley very unfriendly; so much so, that I found it necessary to remind him I had called on his invitation, that I had not come to quarrel, and that I would not be provoked into a quarrel.

In the course of our discussion, as a consequence of my informing Mr. Culley that there were about 1,200 of my undemagnetisable instruments on the North-Western Railway, some of which had been working nearly six years, and all of them for over three years, and that all of the instruments were protected by my lightning bridges, a letter was dictated by Mr. Culley to Mr. Newman, the electrical engineer of the North-Western Railway Company.

Now Mr. Newman had taken no part in the discussion on Mr. Preece's paper, but what, I presume, was his reply to Mr. Culley's letter, appears as part of the discussion in the published Proceedings of the Society of Telegraph Engineers, my speech being *wholly* suppressed; and the reason, I take it, for publishing Mr. Newman's communication was, that it stated generally, cases had occurred where my coils had been fused, no details whatever being given.

On December 21st, to my surprise, I received a letter from Mr. Culley, enclosing one for publication, addressed to the *Engineer*, which I was asked to forward, if I approved of it. This letter was posted by me, and published in the *Engineer* of December 27th, 1872, and it reads as follows:—"I feel it due to Mr. S. A. Varley to say that in supplying his carbon lightning bridge to the Post Office, he proposed to connect it to the earth at every station: for reasons of my own, not connected with science but simply with discipline, I preferred not to connect it to earth at the intermediate stations. The impression produced during the recent discussion at the Society of Telegraph Engineers was, that this arrangement was part of Varley's system. This impression I wish to remove, for looked at from a scientific point of view alone, the arrangement adopted is clearly not as efficient as that proposed by S. A. Varley.—(Signed) R. S. Culley."

I have gone into the above details because Prof. Ayrton throws inferentially a doubt on my *bona fides*, and I wish to say that if the Council of the Electrical Engineers would desire to investigate the matter I am quite ready to submit to be cross-examined, on the condition that I be allowed to cross-examine Mr. Culley, Mr. Preece, and Prof. Ayrton, and also on the understanding that the whole of what transpires be published.

Prof. Ayrton says: "I quite fail to represent the fact" when I give the credit to Mr. Dredge for having unearthed the 1854 provisional specification of Hjorth.

It appears, although I was not aware of it, that he himself made a search of the patent records a few years before Dredge did, which he communicated to the Society of Telegraph Engineers in 1879, that is to say, three years, but three years only, before Mr. Dredge published his "Electric Illumination," from which most of us learned of the existence of the 1854 specification of Hjorth.

Prof. Ayrton charges me with a want of generosity to Hjorth. This is what I published in my reference to Hjorth: "If a machine acting as described in the Hjorth specification of 1854 had been *actually* made it would have been an approach to the dynamo principle, and machines of the pure dynamo type would in all probability have been produced at an earlier date than 1866."

What more, I ask, could be fairly said of a machine which was *never* made, and which, as described, was not a machine of the pure dynamo type, as mine was. Mr. Hjorth, too, was a man not unknown to electrical engineers of this country; and his machine, had it ever been constructed, would have been a sufficient advance to have left some record of its existence.

It does not lay to Prof. Ayrton to charge me with a want of generosity. I would ask, is it generous of Prof. Ayrton to refer to Cornelius Varley as a joint discoverer of the dynamo principle after my having explained he had nothing to do with it? Was it generous in the introduction to "Electricity in the Service of Man" for his partner to refer to my discovery in such a way that nine out of ten would think he referred to my late brother and not to myself? Was it generous, to use the *very mildest* term possible, for Prof. Perry to tell the students he lately addressed that it was my late brother who discovered the dynamo principle, when he well knew it was myself who made the discovery?

Was it generous on the part of his colleague, Dr. Silvanus Thompson, to omit all reference to my 1866 machine in the first and second editions of his work on dynamo-electric machinery? And was it generous of him in his last edition to refer to it only in the preface, and in a misleading manner?

I must say a few words in reference to Prof. Ayrton's insinuation that I did not grasp the dynamo principle when I constructed my 1866 machine. I may mention the specification describing my 1866 machine was drawn up four months after the machine had been made and worked, and it was drawn up very hurriedly. I maintain that the passage which occurs in my specification, which a *few* of our mathematical physicists are ungenerous enough to try and twist from its common sense meaning, shows that I fully grasped the dynamo principle in the spirit of an engineer, and not as a mere amateur. The passage in my specification Prof. Ayrton refers, to reads thus: "We *generally* send an electric current through the electro-magnets before using the machine; the object of this is to secure a small amount of *permanent* magnetism in the direction we wish." As a matter of fact, before I started my machine for the first time I sent a current from 10 cells of a sulphate telegraph battery having a high internal resistance, and the machine started itself immediately it was set in motion.

I suppose Professor Ayrton would wish to be considered not an amateur, but an electrical engineer, having a working and a greater practical knowledge than those physicists who, according to Professor Perry, lectured and wrote upon electricity up to 1870, men who were, many of them, very able mathematicians, but who had not seriously studied electricity.

All those who deserved to be called electrical engineers long before 1866 were well aware that soft iron was capable of being permanently magnetised, and that the magnetic polarization of the ordinary soft iron of commerce could not be reversed by simply altering its position in respect to our terrestial magnet.

When you construct electro-magnets of several pieces of the iron of commerce the chances are the magnetism existing in one part opposes and balances that of the other, and for this reason, as you must have a fulcrum, however small, to resist the mechanical motion, dynamos as a rule require a small amount of permanent magnetism to be imparted to them to enable them to start in the first instance.

Is it not in very bad taste, after the work I have admittedly accomplished for younger men, such as Professors Ayrton, Perry and Silvanus Thompson, to charge me with ignorance of the elementary principles of magnetism as they do? I am myself disposed to think that although considered as so many yards of measuring tape, they are by far my superiors. They have not been able even yet to grasp *as knowledge*, the dynamo principle in its entirety, as fully, as I have done.

Prof. Ayrton's colleagues as late as last year declared in the law courts my specifications bristled with scientific absurdities, and Lord Trayner, at the Court of Sessions, Edinburgh, asked Prof. Ewing, whom Ayrton will admit to be an authority on magnetism, whether there was any manifest absurdity in a certain passage, strongly animadverted upon by Prof. Ayrton's colleagues, and Prof. Ewing replied, "On the contrary, what Mr. Varley there states, as well as what appears in other passages in his specification, shows Mr. Varley's knowledge to have been very much in advance of his time."

It is easy to indulge in platitudes, as Prof. Ayrton has done in the latter part of his letter. Your readers can form their own judgment as to who of the contending parties writes the most straightforwardly.

I have now only to say that I have not written with a light heart any one of my letters; they must necessarily give offence in some quarters, and I think it very probable I shall not please many whose good opinion I value, for, whilst my friends will agree with much that I have stated, some of them will probably be of opinion that it would have been better not to have raised the veil.

I have been patient and long-suffering. No one can fairly charge me with being grasping or anxious to advertise myself, but there is a limit to one's patience; nevertheless, I should never have written what I have done, did I not feel that what really amounts to a scandal has grown up in our midst since the booming of the electric light companies.

Since I was looked up in 1885 my name has come somewhat prominently before the electric industry, and what may be described as a fight between Prof. Ayrton's colleagues and myself has since that period been going on. I have been doing my best to ameliorate the burdens which oppress the electric industry, and Prof. Ayrton's colleagues have been doing their best to forge fetters which will hold the industry in bondage. I am naturally pleased that so far victory has been on my side, and that of the electric industry as a whole.

S. Alfred Varley.

Submarine Cables.

I should feel much obliged to get an answer to following question:—Suppose a submarine cable connects two distant coasts, say 400 miles; a fault arises about 20 miles from the one coast but without causing interruption in correspondence, only weakens the current. Will there be any difference in the work on the cable at the two coasts, supposing the E. M. power used is equal and both cables have only short land-lines?

Tynesider.

[The signals received at the end of the cable furthest from the fault will be weaker than those received at the other end; the signals also will be more irregular; much, however, depends upon the nature of the fault.—EDS. ELEC. REV.]